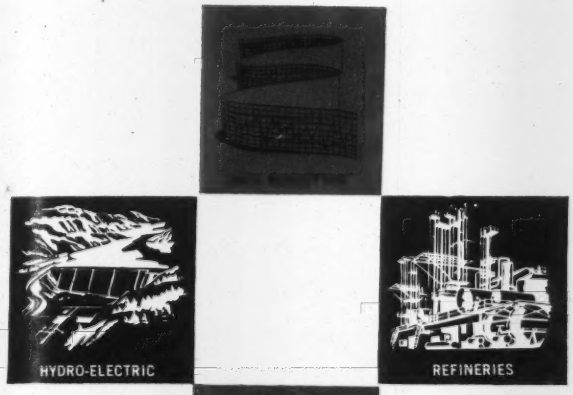
INSTRUMENTS and AUTOMATION

Phys.



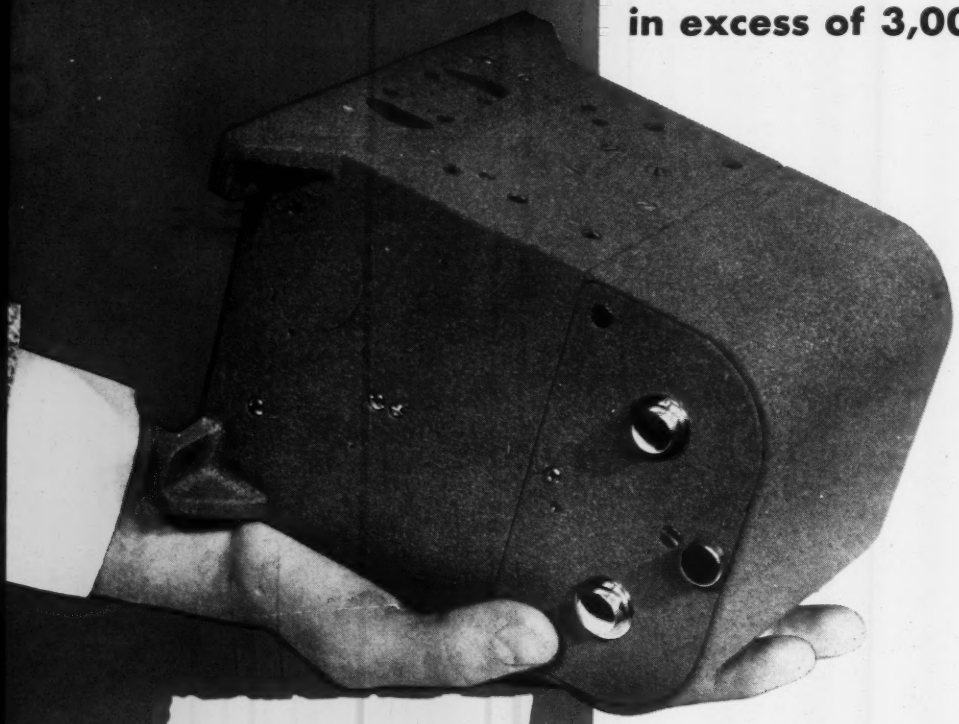
General-Purpose Digital Computer . . . page 1773

Including: **Instrument Manufacturing**
The Journal of the SCMA
Simulation Council Newsletter

EPTEMBER 1956

the MIDWESTERN 560B OSCILLOGRAPH . . .

designed and tested to withstand shock accelerations in excess of 3,000 gravities . . .



See this oscillograph and other Midwestern test instruments and servo components at the

ISA SHOW — Booth 1305
Sept. 17-21

other midwestern products

- OSCILLOGRAPHS (Laboratory and Flight Test)
- MAGNETIC STRUCTURES
- GALVANOMETERS
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- BRIDGE BALANCE UNITS
- HYDRAULIC SERVOVALVES
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This miniaturized 14-channel oscillograph has been subjected to extremely high shock accelerations and by the use of shock-delay techniques, has recorded all data associated with them. Some of its many features are — $3\frac{5}{8}$" x 50 foot record capacity • $\frac{3}{8}$ to 8 inches per second recording speeds • ability to record while subjected to constant accelerations of 20 gravities • $5\frac{3}{4}$ x $6\frac{5}{8}$ x $7\frac{1}{16}$ inches overall dimensions • operated from 28 volt dc power sources.

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For more information circle 1 on inquiry card.

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In addition to the 28 volt models featured at the right, the following units are also available:

OTHER 28 VOLT MODELS

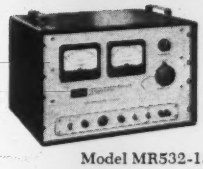
Model	Volts	Amps	Reg.	AC Input (60 cps)	Ripple rms
[illegible]	0-32 V	5	20% (24-32 V range)	115 V 1 phase	2%
[illegible]	24-32 V	10	±1%	100-125 V 1 phase	1%
[illegible]	0-32 V	15	20% (24-32 V range)	115 V 1 phase	5%
[illegible]	24-32 V	50	±1%	230 V* 3 phase	1%
[illegible]	24-32 V	200	±1%	230 V* 3 phase	1%
[illegible]	24-32 V	300	±1%	230 V* 3 phase	1%
[illegible]	24-32 V	500	±1%	230 V* 3 phase	1%

*±10%. Also available in 460 V ±10% AC input. Will be supplied with 230 V input unless otherwise specified.

6, 12, 115 VOLT (NOMINAL) MODELS

Model	Volts	Amps	Reg.	AC Input (60 cps)	Ripple rms
[illegible]	6 ±10%	5	±1%	95-130 V 1 phase	1%
[illegible]	6 ±10%	15	±1%	95-130 V 1 phase	1%
[illegible]	6 ±10%	40	±1%	95-130 V 1 phase	1%
[illegible]	12 ±10%	15	±1%	95-130 V 1 phase	1%
[illegible]	115 ±10%	5	±1%	95-130 V 1 phase	1%
[illegible]	115-125	5	±1%	95-130 V 1 phase	1%
[illegible]	115-125	25	1%	230/460 V 3 phase	5%

**Corrosion Rectifier Unit. Increases to 2% @ 15 V.



Model MR532-15A

2-36 VOLTS @ 15 AMPS SPECIFICATIONS

Regulation:	5-32 Volt Range: ±½% 2-5 Volt and 32-36 Volt Range: ±2%
AC Input:	105-125 Volts, (for 2-32 V.DC), 110-125 V, (for 32-36 V.DC), 1 phase, 60 cps (8 amps)
Ripple:	1% rms max. (@ 36 volts and full load. Increases to 2% @ 2 volts and full load).

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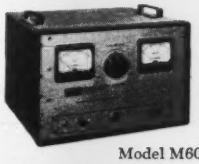


Model M60V

0-32 VOLTS @ 25 AMPS SPECIFICATIONS

Regulation:	±1% @ 28 Volts (Regulation increases to 2% over range of 24-32 volts; does not exceed 2 volts over 4-24 volt range. Not stabilized for AC line changes.)
AC Input:	115 Volts, 1 phase, 60 cps (12 amps).
Ripple:	1% rms (@ 32 volts and full load—2% rms max. @ any voltage above 4 volts).

Model MR1040-30A

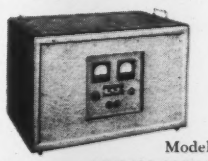
5-40 VOLTS @ 30 AMPS SPECIFICATIONS

Regulation:	±1% (over entire 5-40 volt range)
AC Input:	100-130 Volts, 1 phase, 60 cps
Ripple:	1% rms

Model 28-30 WXM

24-32 VOLTS @ 30 AMPS SPECIFICATIONS

Regulation:	±½%
AC Input:	100-125 Volts, 1 phase, 60 cps (20 amps). (Unit rated for DC output of 28 volts ±10% for 95-130 volt input.)
Ripple:	1% rms



Model MR2432-100XA

24-32 VOLTS @ 100 AMPS SPECIFICATIONS

Regulation:	±½%
AC Input:	208, 230 or 460 Volts, ±10%, 3 phase, 60 cps (14, 12 and 6 amps respectively). 230 volt input will be supplied unless otherwise specified.
Ripple:	1% rms

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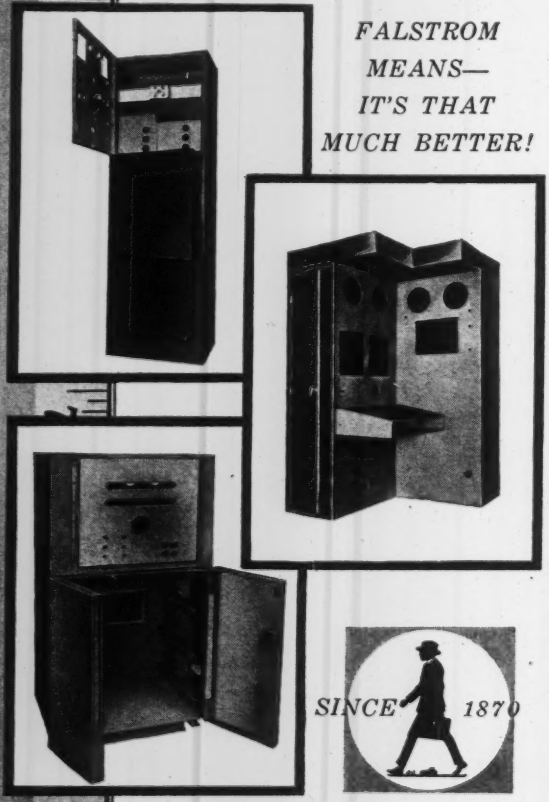

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Inquiries Invited. Write Dept. IA-2.

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For more information circle **4** on inquiry card.

INSTRUMENTS and AUTOMATION

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September 1956

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Altadena, Calif., Milo D. Pugh & Associates: M. D. Pugh, 2721 N. Marengo Ave., SYcamore 7-2894; Hunter Vinton, 1050 Lincoln Ave., Palo Alto, Calif., Davenport 5-4815

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Editorial

An Engineer Looks Inward 1759

Feature Articles

Automatic Data Reduction 1767
Martin Klein, Frank K. Williams and Harry C. Morgan

The G-15 Digital Computer 1773
S. Herbert Lewis

Electronic Circuitry 1780
Charles F. Kezer and Milton H. Aronson

Positioners for Diaphragm Actuators 1782
C. S. Beard

Flight-Table Instrumentation 1789
Robert H. Esling

The Simulation Council Newsletter 1793

Journal of the Southern California Meter Association

Recent Developments in Solenoid Valves 1800
Frank E. Reeves

Other Regular Features

Letters to the Editor	1699	Biographies of Significance	1745
Inquiries	1705	New Instruments	1810
Trends	1707	Briefs	1868
Panhandle Pete	1711	New Literature	1878
News	1712	Searchlight Section	1888
Stock Report	1726	Advertisers' Index	1890
Events Calendar	1742	Inquiry Card	1891
Books	1764		

THE MAGAZINE OF INSTRUMENTATION AND AUTOMATIC CONTROL FOR 28 YEARS – SINCE JANUARY 1928

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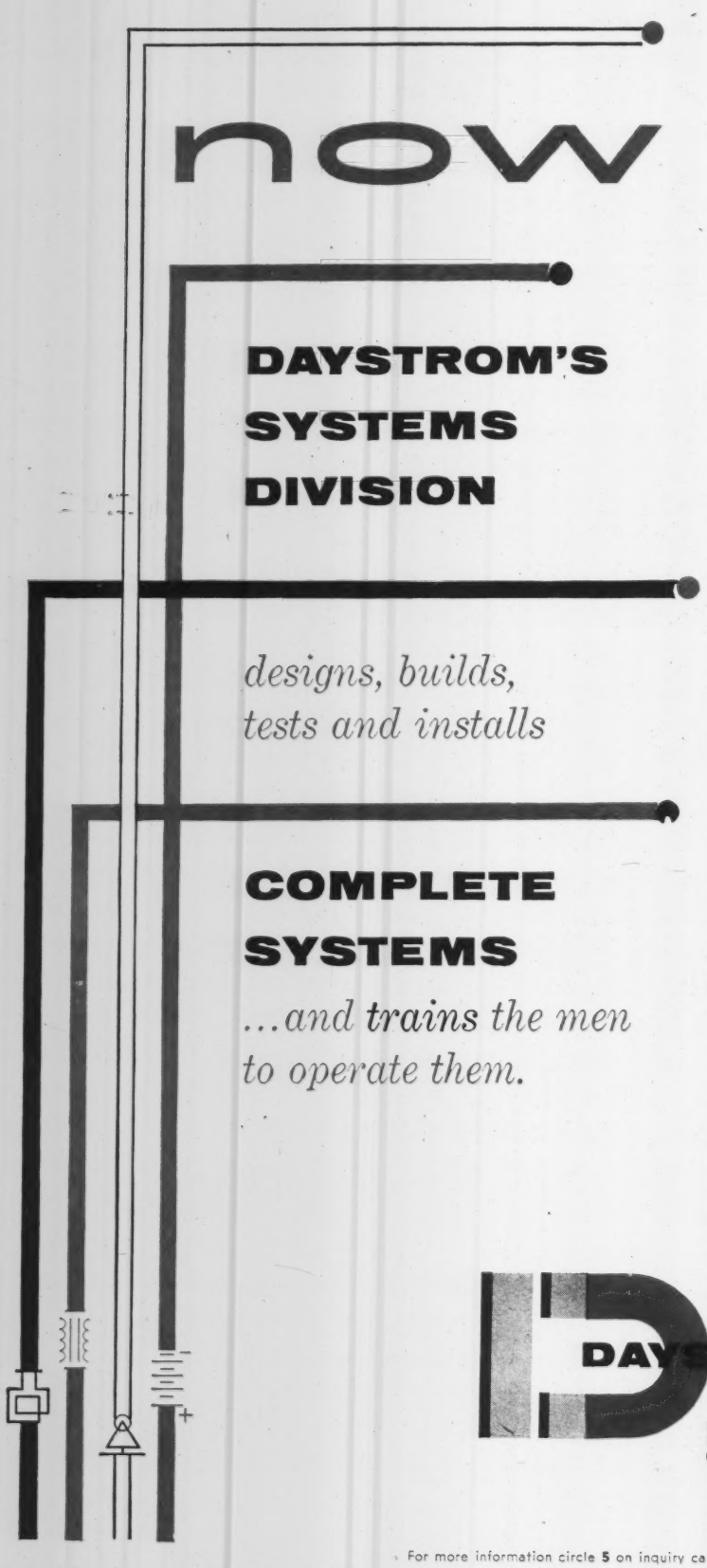

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For more information circle **5** on inquiry card.

Letters to the editor

Editor, I&A:

Hearty congratulations on your excellent editorial, "THE SOCIAL REACTOR—ABOUT TO EXPLODE?", which appeared in July 1956, *Instruments and Automation*. You've done a magnificent job, as always, in pointing out for your readers one of the basic needs of our time—"Education . . . becomes the real source for the raw fuel—and the teacher becomes the truly key element".

The Public Relations Committees of the Laboratory Apparatus and Optical Sections along with the help and interest of our Public Relations Committees from the Recorder-Controller and Laboratory Equipment Sections have been aware of this basic national need for many years.

You will probably be very interested, then, in looking over the enclosed three reports that I recently sent out to all concerned SAMA members which should certainly give you a bit more grist for your excellent editorial philosophy of finding more good science teachers and more capable science students.

James R. Irving
Director of Public Information
Scientific Apparatus
Makers Association
Chicago 6, Ill.

The Public Information Committee, Laboratory Apparatus and Optical Sections, SAMA, has proposed a National Science Week, and has enlisted the aid of key professional societies, various governmental committees, the National Science Foundation, and others. Emphasis will be on science instruction at all school levels, dramatization of science, scholarship opportunities, community advisory boards in science, rural education in science, etc. This idea merits the support of the entire technical fraternity.

Editor, I&A:

In the event you have not already received a copy, we are enclosing a RETMA Engineering Department Press Release covering the RETMA Automation Committee Definition of Automation.

J. A. Caffiaux
Staff-Engineer
Radio-Electronics-Television
Manufacturers Assoc.
11 W. Forty-Second St.
New York 36, N. Y.

The RETMA Staff Committee on Automation, under the chairmanship of Mr. W. Hausz, has formulated this definition: "Automation is the technique of improving human productivity in the processing of materials, energy and information by utilizing, in various degrees, elements of self-control and of automatically executed product programming."

Your editor formulated the following definition of automation in 1954: "Automation is the use of devices—mechanical, pneumatic, hydraulic, electrical and electronic—for making automatic decisions and efforts."

Let's take a poll. Which definition do you prefer?

Editor, I&A:

Can you help me with the following problem?

A deep-well multistage turbine pump is to be installed in a well at a depth of 1000 feet *below* land surface. The static water level of the formation, before the pump is started, is 150 feet *above* land surface. The clearance between the well casing and the pump discharge column is almost non-existent in certain places, possibly as little as one-eighth of an inch, because the well is crooked. This lack of clearance prevents use of the conventional copper air-line for measurement of pressure and drawdown. Nevertheless it is necessary for the well operator to be able to determine the water pressure at the pump intake at any time so that the pumping rate may be reduced before the pump breaks suction, and for other operational purposes.

The situation would seem to call for a pressure-gage of some sort (the smaller the better) which could be mounted on the outside of the pump between the stages and which would be connected to an indicator (or possibly a recorder) at the land surface. Range of the gage should be 0-500 psi and it should be accurate to the nearest 0.5 psi. The gage will be immersed in water the temperature of which is about 120°F. Reliability is of prime importance as it is not feasible to replace the sensing device (or the wires leading to it) except when the pump is removed for replacement or overhaul. The pump and discharge column is subject to a certain amount of vibration when water is being pumped.

Raphael G. Kazmann,
Consulting Engr.,
Stuttgart, Ark.

This problem has some unusual implications, so we have published it as a "letter to the Editor" rather than as a conventional "Inquiry."

Editor, I&A:

We are, of course, happy to see the mention of the Remington Rand Univac in your "News Bits" column in the December 1955 issue of "Instruments and Automation." We know that your publication is widely read by everyone interested in this particular field, and information about our computer in *Instruments and Automation* is always, of course, welcome.

We find it necessary, however, to call your attention to the fact that "Univac" is a registered trademark, owned by this company.

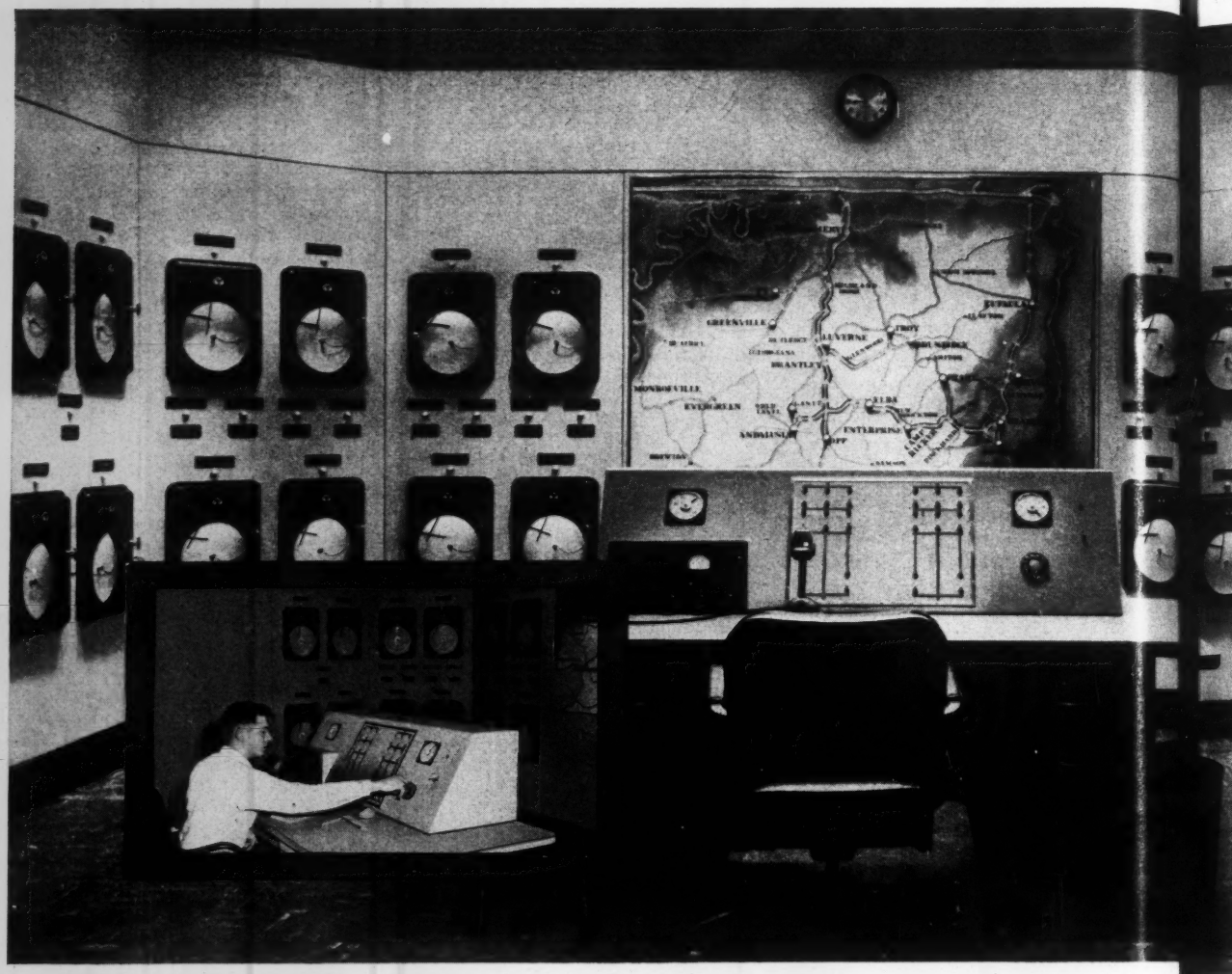
A. C. Hancock
Remington Rand
New York, N. Y.

We used the word in the news releases as follows: "Univac." We neglected to mention Remington Rand because we felt almost everyone now associates the name with Remington Rand, automatically. Such is the penalty for success in name promotion.

Editor, I&A:

There are one or two things I have long intended writing about. Brickbat first—bouquets after!

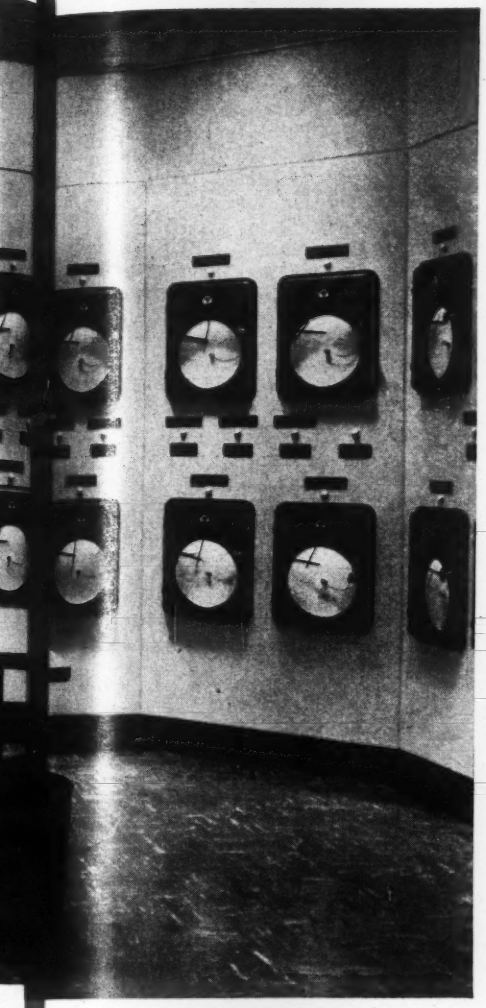
(1) The restriction to the U.S.A. and Canada only of the "Readers Enquiry Card" is a blow! Maybe your advertisers decided this for you on the score of cost of postage; if so, it is not good for them in the long run. Although myself and other readers here may make few purchases as a result of the data we receive, it must not be overlooked that we are frequently able to advise people needing



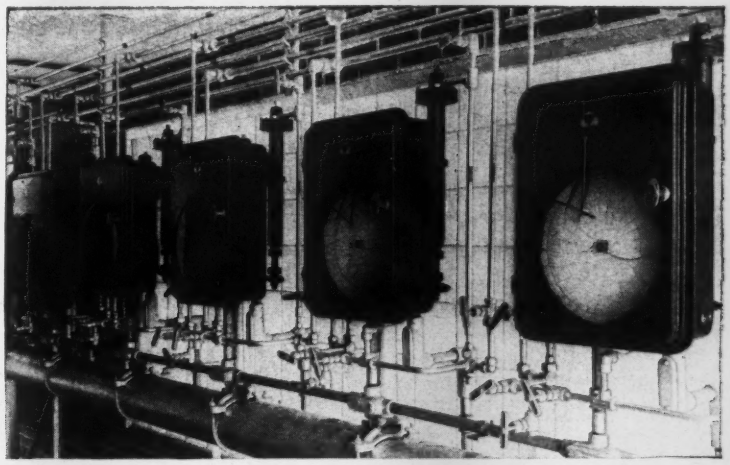
Remote Control of Flow and Pressure for 24 cities and towns in Alabama

ANOTHER ALL AMERICAN® INSTALLATION — From a centrally located desk in Andalusia, Alabama, one dispatcher, by remote control, regulates the flow of gas for the 24 cities in the Southeast Alabama Gas District—largest municipal natural gas system in the world. The 120 years engineering and precision manufacturing experience of American Meter Company assisted by supplying equipment for this new type modern gas measurement and control installation to bring the advantages of natural GAS to one of the fast-growing areas of the United States.

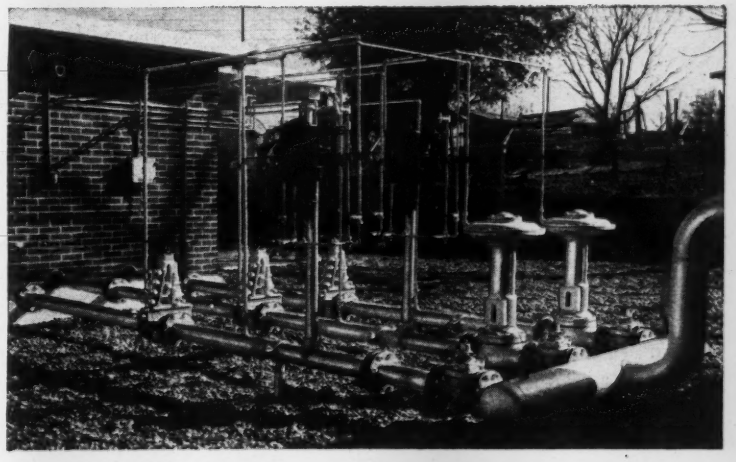
For more information circle **6** on inquiry card.



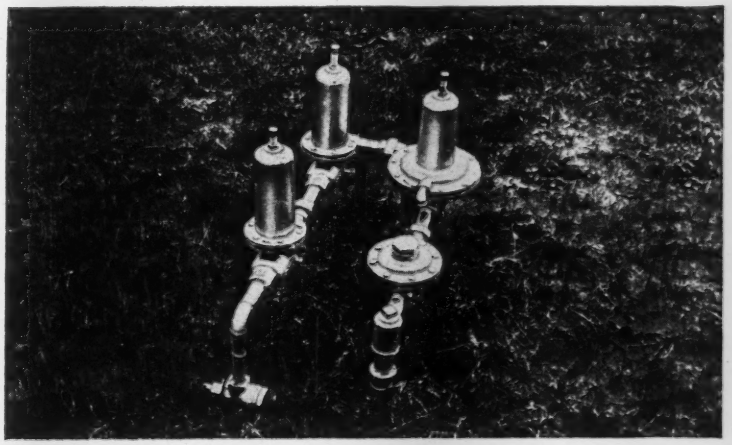
DISPATCHER STATION – By dialing a single circuit, dispatcher obtains total flow in cubic feet and pressure from each of the 14 city gate stations, plus total flow in cubic feet, pressures and differentials of orifice meters and controllers at each intake station to permit complete remote dispatching.



INTAKE STATIONS – All measurement at intake stations, 90 miles and 120 miles from dispatcher's desk, is combined in a totalizing relay which in turn is put on a memory relay to supply total flow since last dialing.



CITY GATE STATIONS – Each station has American automatic measurement, pressure and regulation equipment, totalizing relays and memory relays, enabling dispatcher to obtain flow for any period and obtain pressures. Complete remote control of dual flow differentials, dual first and second stage regulators.



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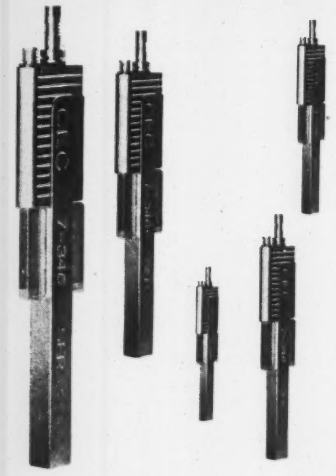

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Natural Frequency (cps)	100	225	320	150	335	100	225	335
Sensitivity (μa/in)*	6.13	10.8	27.2	10.2	24.3	6.8	15.1	34.7
Source Impedance (for .64 damping)	350	350	350	180	180	120	120	120
Standard Balance (in/g)*	.012	.008	.008	.008	.008	.008	.008	.008
System Voltage Sensitivity (mv/in)*	2.43	4.673	10.94	2.20	6.29	1.46	3.17	6.060

*For standard 11.5" optical arm

CEC

Consolidated Electrodynamics

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For more information circle **7** on inquiry card.

LETTERS—CONTINUED

the goods of where they can be obtained and the prices.

(2) Somewhere along the line the address of my copies has been changed to the Company name; it is my *personal* subscription.

Now for the bouquets!

(1) In company no doubt with thousands of your other readers, I am grateful for the courtesy you extend in having your feature articles arranged to be read from start to finish without the infuriating pursuit of tail-ends through the advertisements in the latter part of the journal!

(2) The standard of your articles, their layout and illustration, and the evidence of capable sub-editing, are highly appreciated. The same goes for the extent of coverage of the "New Instrument" field. In short, an indispensible journal for the instrument man and all others who have to deal with instruments.

V.J.G. Harding
N.S.W. Mining Company Pty. Ltd.
Sydney, N.S.W.,
Australia.

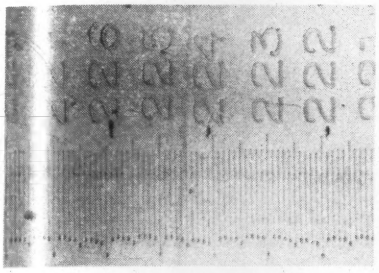
The reason we restrict our reader service card to the USA and Canada is not because of the cost of processing the inquiry, but because many American instrument producers are not in position to do business abroad—that is, they do not have export agents or representatives abroad and hence cannot follow up the inquiry properly. Business of this type should be done by direct communication.

As to continuing articles in the rear of the book, the reason other publications do this is to place reading matter near advertisements and thus benefit the advertiser. The reader's subscription price does not nearly pay for a quality publication; most of the cost is borne by the advertiser, and hence you should forgive those publications who try to benefit their advertisers in this manner. We do not resort to this technique because we enjoy enough support from advertisers in general that we can afford to bring you an uninterrupted extensive feature-article section plus enough other material to place all advertisements near interesting reading matter. It is of interest to note the interdependence of reader and advertiser. By subscribing, you make it economic for the advertiser to advertise. By advertising, the advertiser makes it economic for the publisher to offer you a publication that you enjoy. As in all of life, we depend each on the other.

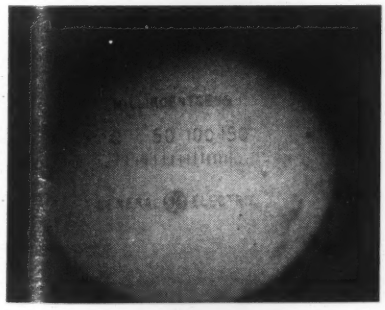
Editor, I&A:

In March of 1947, you published a short article which I wrote on "Microscopic Ruling."

We have been out here in this most beautiful (to us) part of the country for nearly five years and are carrying on much the same as we did back east but with considerably less tension. I thought it might interest you to know that I have been doing some extremely minute micro engraving on metals, notably stainless steel. Actually I have, experimentally, produced diamond engraving on glass at the rate of over twelve million words per square inch. The enclosed photograph is of a scale ruled



in hundredths of a millimeter at the Bureau of Standards in Washington on a small bar of stainless steel. It was sent out to me for numbering. The numbers are but 0.002" tall. The entire scale was sixty millimeters long and numbered every tenth millimeter.



The other photograph is of an engraving, done with a diamond, on the end of a highly polished stainless steel rod one eight inch in diameter. The familiar GE circle is about three tenths of a millimeter in diameter. Other similar work has been done here and I am led to wonder if there is much interest in such work. In any event I do marvel at your enterprise and thank you for your informative publications.

Lyman Nichols
Cherryhurst,
Fort Collins,
Colo.

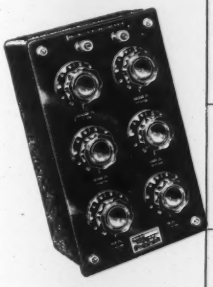
DECADE RESISTANCES & VOLTAGE DIVIDERS

delivered from stock

Accuracy: 10 ohms and above: ±0.1%
1 ohm: ±0.25%
0.1 ohm: ±1%
0.01 ohm: ±5%

Temp. Coeff.: ±0.002% per degree C.
Maximum Load: ½-watt per step
Frequency Limit: Non-inductive to 20KC

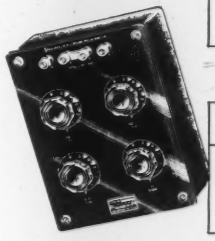
DECADE RESISTANCE BOXES



Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
817	3	0.01	11.1	$60.00
818	3	0.1	111	51.00
820	3	1	1,110	56.00
821	3	10	11,100	60.00
822	3	100	111,000	63.00
823	3	1,000	1,110,000	77.00
824	3	10,000	11,100,000	120.00
817-A	4	0.01	111.1	75.00
819	4	0.1	1,111	71.00
825	4	1	11,110	77.00
826	4	10	111,100	79.00
827	4	100	1,111,000	92.00
828	4	1,000	11,110,000	139.00
8285	5	0.1	11,111	94.00
829	5	1	111,110	101.00
830	5	10	1,111,100	113.00
831	5	100	11,111,000	155.00
817-C	6	0.01	11,111.1	105.00
8315	6	0.1	111,111	109.00
832	6	1	1,111,110	121.00
833	6	10	11,111,100	169.00

UNMOUNTED DECADE RESISTANCES

Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
435	1	0.1	1	$12.00
436	1	1	10	13.25
437	1	10	100	13.25
438	1	100	1,000	15.00
439	1	1,000	10,000	16.00
440	1	10,000	100,000	18.50
441	1	100,000	1,000,000	32.50
442	1	1,000,000	10,000,000	60.00



DECADE VOLTAGE DIVIDERS (Potentiometers)

Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
845	3	1	1,000	98.00
837	4	0.1	1,000	126.00
835	4	1	10,000	132.00
836	4	10	100,000	146.00

SHALLCROSS MANUFACTURING COMPANY
510 Pusey Ave., Collingdale, Pa.

Shallcross

For more information circle 8 on inquiry card.

PRODUCTION ENGINEERS

JOIN THE LEADER IN AERO CONTROLS!

Honeywell needs top-notch Process Engineers at all levels of responsibility for directing the production of such *airborne* control systems as:

INERTIAL GUIDANCE
INLET AREA CONTROL
JET ENGINE CONTROL
FIRE CONTROL AND BOMBING
FLIGHT CONTROL SYSTEMS
FUEL MEASUREMENT AND MANAGEMENT
EXHAUST GAS TEMPERATURE INDICATION

Engineers selected will analyze designs, establish process methods and control, and guide designs toward economical and speedy production.

■ To qualify, you should be familiar with process evaluation, cost estimating, tool ordering, metals fabrication, and manufacturing-assembly operations. Your background should be in the area of *precision* electrical, mechanical, or hydraulic devices such as gyros, accelerometers, operational computers, pressure switches, amplifiers, calibrators, altitude compensators, and thermistor level switches.

■ These are permanent, career-building positions that Honeywell can offer because of its succession of achievements in airborne control systems, broad diversification, and healthy balance between civilian and military contracts.

CONSIDER THESE ADVANTAGES

■ Minneapolis offers you metropolitan living with a suburban way of life . . A city of beautiful lakes with every recreational facility a few minutes from your home.

■ Outstanding educational opportunities . . . Liberal tuition allowances paid by Honeywell.

■ Plant and technical facilities among the best in the industry.

■ Honeywell pays your family moving expenses.

■ Salaries, insurance-pension programs are all first rate.

■ Honeywell, the nation's leading supplier of control systems, manufactures over 10,000 diversified products. A sound growth company, Honeywell offers continuing expansion and permanent opportunities for you to advance.

WRITE TO US

If you are interested in a career at Honeywell, call collect or send your resume to Bruce Wood, Technical Director, Dept. IA-9-108, Aeronautical Division, 2600 Ridgway Road, Minneapolis 13.

MINNEAPOLIS **Honeywell**
First in Controls

INSTRUMENTS and AUTOMATION Inquiries

These inquiries, representing problems facing readers of **Instruments & Automation**, are published as a free service to our readers.

Weather Indicator

Reader seeks indication of wind pressure and velocity, temperature, barometric pressure, humidity, etc. in one instrument, or instruments with as many combinations as possible. A-133

Multiple Running Time Recorder

Shoe manufacturing company seeks multiple recorder for registering openings and closings of five hydraulic presses, with running cycles of four to five minutes, and two-minute opening periods. A-134

Air Flowmeter

Contractor in air conditioning field seeks air flowmeter "that is absolutely accurate." A-135

Automatic Batch Weighing Scale

Vitrified china manufacturer seeks automatic batch weighing scale such as used on automatic forming presses of the injection molding type. A-136

Glass and Ceramics Instrumentation

Economist in Research Institute seeks information (also bibliography) on extent and order of magnitude of use of high-accuracy temperature controllers for glass furnaces and ceramic kilns. A-137

Control by Refractive Index

Manufacturer of differential refractometer is seeking advice for application of refractive index measurement for process control. A-138

Pump Identification

British manufacturer is seeking supplier of "Bantam Centrifugal Pump" described as made from polyethylene, driven by a 1/35-hp motor. A-139

Cleaning Machine

Purchasing agent for shock-mount manufacturing company seeks instrument cleaning machine, preferably chemical solution tank with stirrer, containing a basket. Capacity: 5 gals. A-140

Dewpoint Tester

German refinery seeks dewpoint tester with range to plus 17° F, for dehydration unit. A-141

Plastic Fresnel Lenses

Advertising specialists are trying to locate source of supply for magnifying molded plastic Fresnel lenses. Must be stock items of various size for purchase of relatively small quantities. A-142

Stratospheric TV

Firm in field of missiles and electronics seeks data on "Stratospheric TV"—reconnaissance TV with rapid film processing and projection. A-143

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From the Principality of Leichtenstein Swiss Customs Area

ROLYN ARCADIA (Calif.)

Front Surface Mirrors, Cold Mirrors, Achromatic Beam Splitters, Dichroic Beam Splitters, Monochromatic Interference Filters, Wedge Interference Filters, Heat-Reflecting Interference Filters, Cut-Off Filters, Anti-Reflection Coatings, Heat Protective Coatings and many other thin layers.

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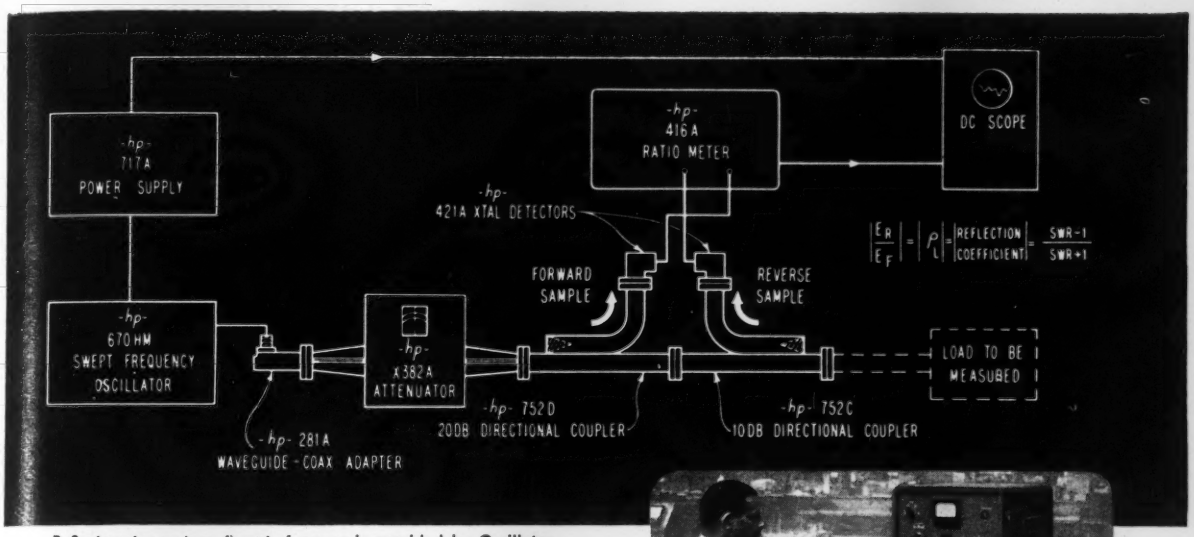
Balzers means research in high vacuum process

For more information circle **63** on inquiry card.



Reflectometer system. Swept rf power is provided by Oscillator. Directional Couplers sample forward and reverse power. Waveguide Detector Mounts terminating both Couplers demodulate power and present a 1,000 cps signal to Ratio Meter. Oscilloscope presents continuous visual study of reflection coefficient over the swept frequency range.

New!

REFLECTOMETER SYSTEM

for fast, accurate, wide range microwave impedance measurements

- **Instantly measures SWR or reflection coefficient**
- **Continuous swept frequency oscilloscope presentation**
- **Ends tedious checking; unaffected by amplitude variation**
- **Systems for frequencies 2.6 to 10 KMC**

This fast, accurate, practical new reflectometer system eliminates hours of tedious engineering in microwave impedance measurements. It gives direct, instantaneous reflection coefficient or SWR readings, ends need for separate forward and reverse power measurements and does away with corrections for amplitude variation. It provides for continuous oscilloscope or recorder presentation and is easily operated by non-technical personnel. The system includes several new *-hp-* instruments:

***-hp-* 416A Ratio Meter,** automatically combining forward and reverse signals and displaying ratio directly; or provides output for oscilloscope or recorder. Unaffected by amplitude variation. $450.00.

***-hp-* 670 Swept Frequency Oscillators,** three models, covering frequencies 2.6 to 10 KMC. Manually tuned or motor driven to sweep any band at velocity insuring good oscilloscope trace. $1,175.00.

***-hp-* 717A Klystron Power Supply,** specially designed to power *-hp-* 670 Swept Frequency Oscillator. *-hp-* 717A, $375.00.

***-hp-* 752 Directional Couplers,** multi-hole couplers having directivity better than 40 db and very accurate coupling factor. Sampled signals are detected with *-hp-* 421A Crystal Detectors and *-hp-* 485 series Detector Mounts. *-hp-* 752 Couplers, $100.00 to $260.00.

For details see your ***-hp-*** *representative or write direct*

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hp® ELECTRONIC MEASURING INSTRUMENTS

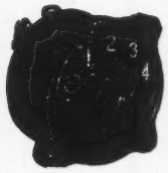
For more information circle 9 on inquiry card.

LEWIS SELECTOR SWITCHES
FOR RESISTANCE THERMOMETERS AND THERMOCOUPLE THERMOMETERS

EACH SWITCH HAS "OFF" POSITION PLUS NUMBER OF POINTS LISTED.

Points	Size	Switch Part Numbers: Thermocouple Type	Switch Part Numbers: 3 Wire Resistance-Thermometer Type
2	2″	11S2	36SR2
3	2″	11S3	36SR3
4	2″	11S4	36SR4
5	3″	10S5	37SR5
6	3″	10S6	37SR6
8	3″	10S8	37SR8
9	3″	10S9	37SR9
10	3″	10S10	37SR10
12	3″	10S12	37SR12
16	3″	10S16	37SR16
18	3″	10S18	37SR18
20	3″	10S20	37SR20
24	4″	27S24B2	38SR24
28	4″	27S28B4	38SR28
40	4″	38S2C	

(No. 38S2C is made with soldering-lug terminals)



2" SIZE

3" SIZE

SPECIAL SWITCHES

No. 37S6C2, Four "4 Point and OFF" thermocouple switches combined in one 3″ case.

No. 9S5, Single Pole, Four Point Instrument Switch in 1¼″ round case.

No. 44S4, Six Pole, Double-throw Instrument Switch in 2½″ round case, one hole mounting, ½-32 threaded bushing.

4" SIZE

DESIGNED FOR TEST WORK AS WELL AS FOR PERMANENT INSTALLATIONS. LEWIS SELECTOR SWITCHES ARE CONSTRUCTED WITH STURDY CONTACTS OF LOW RESISTANCE AND POSITIVE DETENT. THESE SWITCHES ARE SPLASHPROOF, DUSTPROOF AND ARE BUILT TO GIVE YEARS OF SERVICE.

THE LEWIS ENGINEERING CO.

Specialists in Electrical Temperature Measurements

NAUGATUCK, CONNECTICUT

For more information circle **10** on inquiry card.

INSTRUMENTS and AUTOMATION Trends

First big break in industrial simulation—expected to come from the processing industries—may come from the steel industry. Often behind other industries in application of automation equipments, the steel industry may take a progressive leap ahead of all other industries. One major USA corporation has plans for a simulation and analog computer center that will simulate all operations from metallurgical problems to blast-furnace operation. This can be most important development in a decade. We are the first to report it—and we will keep you in touch with all details. See Simulation Council note on page 1797.

UHF and VHF scatter propagation is new technique for trans-horizon communication. UHF scatter (using the troposphere as transmission medium) provides effective reception path lengths up to 350 miles; VHF (using the troposphere for short ranges and the ionosphere for long ranges) provides path lengths to 1200 miles. Work is result of theory of scattering in the troposphere introduced by Booker and Gordon in April-1950 IRE Proceedings. Technique is described in COLLINS SIGNAL, Winter, 1956 issue.

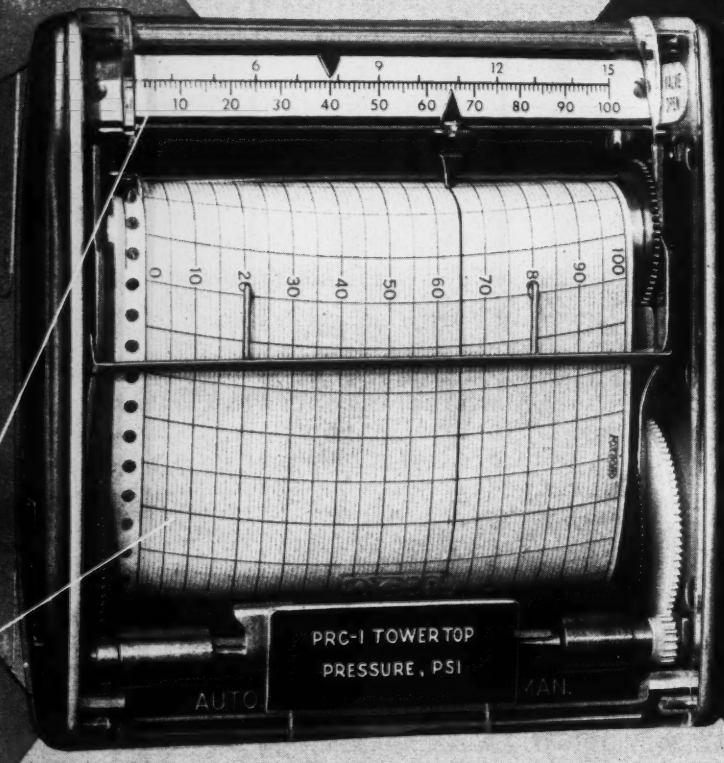
Gas chromatography is being hailed as one of the greatest analytical instrument developments of the past 2 decades (see C&EN, April 9, 1956). Although the word "chromatography" arose from separation of colored matter via absorption, word now applies to any analytical technique for separating mixtures by passing them through a column and forming a two-phase system. As components differ in equilibrium conditions, the time that each component remains in column before it appears at exit (either via elution-partition or absorption-displacement) depends on molecular weight (vapor pressure) for certain cases. Thermal conductivity technique is used for detection. Paper chromatography involves separation of liquid sample in liquid column; gas chromatography involves gas sample with either liquid column (elution-partition) or solid column material (absorption-displacement technique). Reason for interest: instrument is inexpensive and can perform both qualitative and quantitative analysis of materials boiling up to 250°C. Up to 1000 commercial gas chromatography instruments are expected to be sold in 1956. Many companies are now making own instruments—but commercial instruments are emphasizing flexibility.

Forty U.S. airlines have received an Award of Honor for going through 1955 without a passenger or crew fatality, These 40 had an accumulated number of 1,558 million passenger miles without a fatality to end of 1955. Total 1955 passenger death rate was 0.75 deaths per 100 million passenger miles for domestic operations. Aircraft and navigational instrumentation played a key part in this excellent record; is becoming increasingly important.

NOW...

compactness with nothing sacrificed!

Controller mounts integrally



Full 4-inch Width Scales and Charts

Models to Meet All Your Specifications

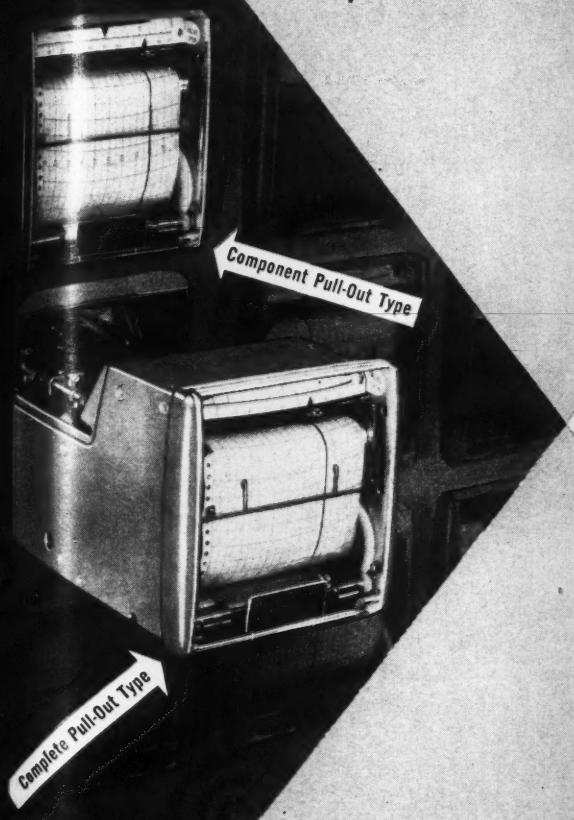
In all the following CONSOTROL instruments, recorder and indicator units can be easily converted in field.

- Recording Control Station with automatic/manual transfer
- Recording Control Station with manual loading only
- Recorder — single or two pen
- Indicating Control Station with automatic/manual transfer
- Indicating Control Station with manual loading only
- Indicator — single or two pointer

For more information circle **11** on inquiry card.

CONSOTROL

small-case panel instruments



Here's the "tops" in centralized recording and control efficiency! CONSOTROL Instruments require the minimum of valuable panel space, yet provide unsurpassed operator convenience, visual accuracy, and ease of maintenance . . . maintain the highest standards of precision and dependability. For example: the simple CONSOTROL method of switching from automatic to manual control requires no memory or extra operations . . . never "bumps" the process. All CONSOTROL charts and scales are full 4-inch width for greatest visibility . . . highest accuracy. When it comes to servicing, there's plenty of "finger room" . . . all parts are uncrowded and easily removable. And just compare inking requirements with other designs. CONSOTROL needs ink filling only once or twice a year! These are only a few of CONSOTROL's advanced design features — available in both fixed-mounting and full pull-out type instruments. Get the complete story. Write for Bulletin 13-18. The Foxboro Company, 469 Norfolk Street, Foxboro, Mass., U.S.A.

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FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

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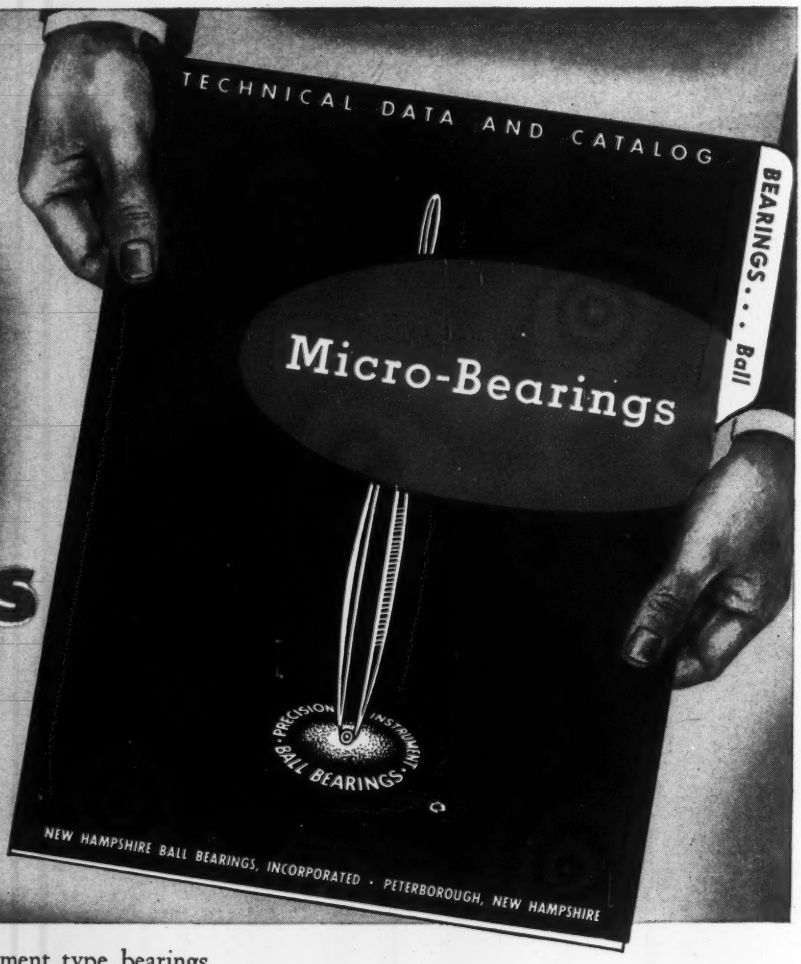
This brand new concept in bearing catalogs will help solve your design problems!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PRECISION INSTRUMENT BALL BEARINGS
NEW HAMPSHIRE BALL BEARINGS, INCORPORATED · PETERBOROUGH, NEW HAMPSHIRE

If you work with small instrument type bearings you'll find this new, authoritative publication an extremely valuable and handy source of engineering data arranged in convenient form for practical reference.

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- A helpful survey article: "FACTORS TO CONSIDER IN SELECTING SMALL INSTRUMENT BALL BEARINGS."
- A complete, practical presentation of bearing facts:

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Materials
Components
Engineering standards
Tolerances
Dynamic and static loads
Lubrication
Radial and Axial play
Torque
Mounting practice etc.

- Large, clear illustrations.
- Big, easy to follow charts.
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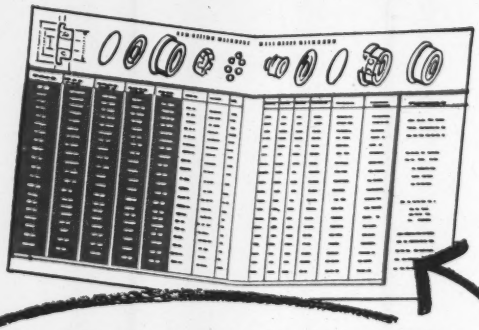

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For more information circle **12** on inquiry card.

The Instrument Salesman

Panhandle Pete

BLUE Monday, September, 1956. Got up early, called the boss at his home, then started down to Weirton and Steubenville to call on Messrs. Francy, Baker and Wallace at Weirton Steel Company and Messrs. Bernstein and Cousley at Wheeling Steel Corporation. It was a beautiful day, not a truck on the highway, and I found my favorite beverage, Old Frothingschloss, at Voyes Inn.

Got stopped at W. Va. state line by Weirton Police. Found out I was the 1,000,000th visitor to Weirton; received key to City Hall, a case of W. Va. whiskey (Moonshine??) and a crate of ducks. Kept whiskey, threw away the key and told them what to do with their ducks. Got hold of Francy, Baker and Wallace and took them to lunch. Francy can't eat as much as he used to before his coronary; now he eats more expensively—don't know whether I'm ahead or not.

Arrived back in mill and started a sales-pitch. Everybody sat and listened, asked intelligent questions and didn't mention my latest faux pas, the one where I sold 'em five barrels of green ink instead of five quarts.

After I had exhausted my sales talk Francy says he is glad I came down. Wanted to buy a Model M1A1 Natural Moisture Recorder. Gave him the dope and thought I'd better leave while still ahead and see if the Wheeling Steel boys were in a mood to buy too. Shook hands, patted backs and told one more story.

Got over to Steubenville OK but couldn't locate Mike or Dave. Both busy? Started back to Pittsburgh and got stopped just on the other side of the Fort Steuben bridge by W. Va. State Police. Found I was the 1,000,000th visitor to the state of West Virginia. Received key to Charleston, a case of whiskey and a crate of ducks. Kept the key, threw away the ducks and told them what to do with their whiskey. For the first time in my life I drove all the way through Weirton without hitting a red light.

Just got a good start on that long hill out of town when Pennsylvania State Police flagged me down. I was the 1,000,000th visitor to the state of Pennsylvania; received the key to Harrisburg, a case of whiskey and a crate of ducks. Kept the ducks, threw away the whiskey and told them what to do with their key. Got home OK. Put whiskey on ice, put key away for future use and put wife to work dressing a duck.

Boss out of town but went to office next day anyhow. Found confirming order in mail from Francy, sent it on to factory and mentally congratulated myself on cracking the sales-resistance barrier at Weirton. Boss back in two days, went in to ask for a raise. Doing fine when telegram for Boss came in from the factory. "Re our order 31416 J 2-1.5 Natural Moisture Recorder. Why is there a three-function control system installed in this instrument? Please confirm. Chief Engineer."

Boss looked at me, raise flew out the window. Called Francy; not in. Called Baker; out. Called Wallace; Wallace says he doesn't know but better furnish instrument as per order. Called Chief Engineer; out to lunch with customer. Called Assistant; out golfing with customer. Called Sales Manager; out swimming with a customer, female. Called Assistant; out drinking with a customer. Got hold of telephone girl. "Nobody in but office boy." Good gawd, doesn't anybody at the factory do any work? Went home.

Back to work the next day in time to take 'phone call from factory. Jeeze, the old man himself! "About this order 31416J2-1.5. Whoever heard of putting a control system on a natural moisture instrument? Everybody knows you can't control the weather! Cancel the order! This company refuses to be made a fool of. Chief Engineer says it would require a 1,000,000,000 #/hr boiler to control the moisture during the winter months. This is ridiculous! If this happens again you will find yourself working for somebody else. . . . . !" Whew!

Called Weirton to get order cancelled. Baker says "Weirton is building a whopping big boiler, No. 5. Better not cancel order or my name is mud again". Whew! Called the old man back. Not in. Out racing his hot-rod. Started down the list; nobody in. Got hold of telephone girl and told her to put office boy on. Lined him up to forge shop order to ship instrument as per customer's order. Refused to answer the telephone rest of day. Looked over the want-ads—went home—don't feel good.

It was a dark and dismal day, no hurry to get to office. Got there at last. Calls from Weirton expeditor—"Wants to know when instrument will be shipped."

Chief Engineer: "Wants to know who in Hades is running his job?" The old man: "Requests a call from you at your earliest convenience," hmmmm. Note from Boss, "Please see me." Oh my gosh. Called Francy; he's in! Find out he added controller to instrument so he could remove it at Weirton and so have a spare controller for his other instruments! Purchasing agent wouldn't let him have a spare. This way he has a spare unit without asking any questions. Any questions? Hey Boss!

Panhandle Pete

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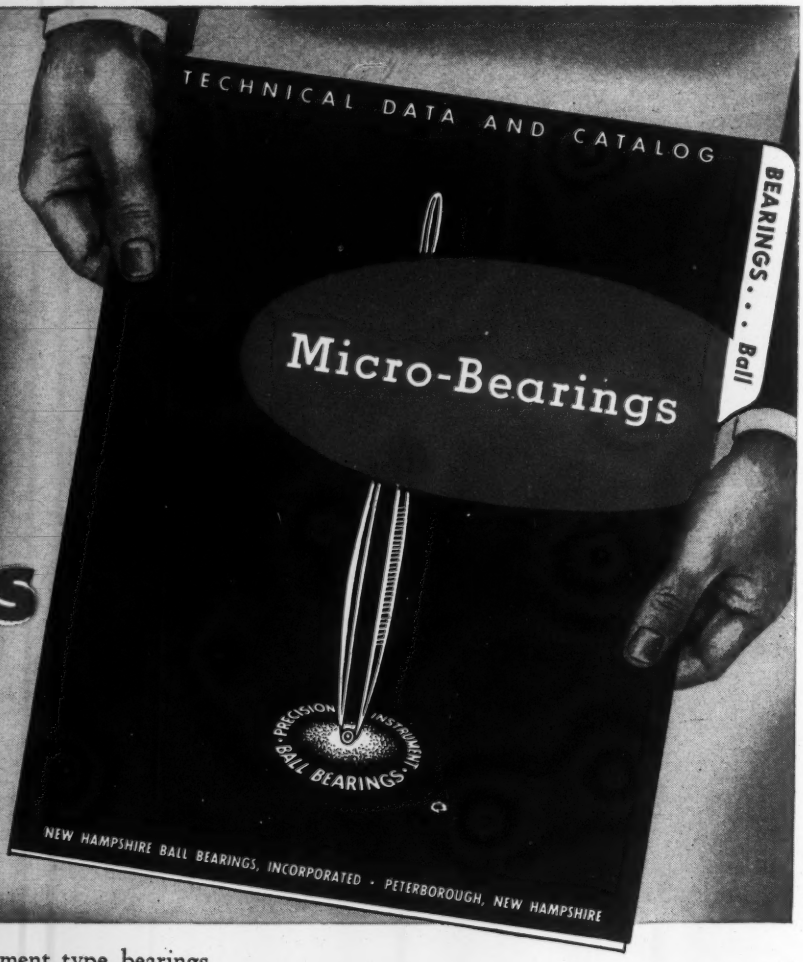
This brand new concept in bearing catalogs will help solve your design problems!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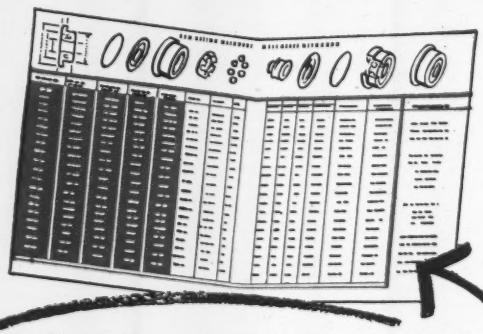
- Convenient nomographs and conversion charts.
- Simple bearing designations make ordering easy.



WRITE TODAY . . . GET YOUR NAME ON OUR PRIME DISTRIBUTION LIST FOR MAILING

NEW HAMPSHIRE BALL BEARINGS, INC., *Peterborough, New Hampshire*

For more information circle **12** on inquiry card.

The Instrument Salesman

Panhandle Pete

BLUE Monday, September, 1956. Got up early, called the boss at his home, then started down to Weirton and Steubenville to call on Messrs. Francy, Baker and Wallace at Weirton Steel Company and Messrs. Bernstein and Cousley at Wheeling Steel Corporation. It was a beautiful day, not a truck on the highway, and I found my favorite beverage, Old Frothingschloss, at Voyes Inn.

Got stopped at W. Va. state line by Weirton Police. Found out I was the 1,000,000th visitor to Weirton; received key to City Hall, a case of W. Va. whiskey (Moonshine??) and a crate of ducks. Kept whiskey, threw away the key and told them what to do with their ducks. Got hold of Francy, Baker and Wallace and took them to lunch. Francy can't eat as much as he used to before his coronary; now he eats more expensively—don't know whether I'm ahead or not.

Arrived back in mill and started a sales-pitch. Everybody sat and listened, asked intelligent questions and didn't mention my latest faux pas, the one where I sold 'em five barrels of green ink instead of five quarts.

After I had exhausted my sales talk Francy says he is glad I came down. Wanted to buy a Model M1A1 Natural Moisture Recorder. Gave him the dope and thought I'd better leave while still ahead and see if the Wheeling Steel boys were in a mood to buy too. Shook hands, patted backs and told one more story.

Got over to Steubenville OK but couldn't locate Mike or Dave. Both busy? Started back to Pittsburgh and got stopped just on the other side of the Fort Steuben bridge by W. Va. State Police. Found I was the 1,000,000th visitor to the state of West Virginia. Received key to Charleston, a case of whiskey and a crate of ducks. Kept the key, threw away the ducks and told them what to do with their whiskey. For the first time in my life I drove all the way through Weirton without hitting a red light.

Just got a good start on that long hill out of town when Pennsylvania State Police flagged me down. I was the 1,000,000th visitor to the state of Pennsylvania; received the key to Harrisburg, a case of whiskey and a crate of ducks. Kept the ducks, threw away the whiskey and told them what to do with their key. Got home OK. Put whiskey on ice, put key away for future use and put wife to work dressing a duck.

Boss out of town but went to office next day anyhow. Found confirming order in mail from Francy, sent it on to factory and mentally congratulated myself on cracking the sales-resistance barrier at Weirton. Boss back in two days, went in to ask for a raise. Doing fine when telegram for Boss came in from the factory. "Re-our order 31416 J 2-1.5 Natural Moisture Recorder. Why is there a three-function control system installed in this instrument? Please confirm. Chief Engineer."

Boss looked at me, raise flew out the window. Called Francy; not in. Called Baker; out. Called Wallace; Wallace says he doesn't know but better furnish instrument as per order. Called Chief Engineer; out to lunch with customer. Called Assistant; out golfing with customer. Called Sales Manager; out swimming with a customer, female. Called Assistant; out drinking with a customer. Got hold of telephone girl. "Nobody in but office boy." Good gawd, doesn't anybody at the factory do any work? Went home.

Back to work the next day in time to take 'phone call from factory. Jeeze, the old man himself! "About this order 31416J2-1.5. Whoever heard of putting a control system on a natural moisture instrument? Everybody knows you can't control the weather! Cancel the order! This company refuses to be made a fool of. Chief Engineer says it would require a 1,000,000,000 #/hr boiler to control the moisture during the winter months. This is ridiculous! If this happens again you will find yourself working for somebody else. . . . . !" Whew!

Called Weirton to get order cancelled. Baker says "Weirton is building a whopping big boiler, No. 5. Better not cancel order or my name is mud again". Whew! Called the old man back. Not in. Out racing his hot-rod. Started down the list; nobody in. Got hold of telephone girl and told her to put office boy on. Lined him up to forge shop order to ship instrument as per customer's order. Refused to answer the telephone rest of day. Looked over the want-ads—went home—don't feel good.

It was a dark and dismal day, no hurry to get to office. Got there at last. Calls from Weirton expeditor—"Wants to know when instrument will be shipped."

Chief Engineer: "Wants to know who in Hades is running his job?" The old man: "Requests a call from you at your earliest convenience," hmmmm. Note from Boss, "Please see me." Oh my gosh. Called Francy; he's in! Find out he added controller to instrument so he could remove it at Weirton and so have a spare controller for his other instruments! Purchasing agent wouldn't let him have a spare. This way he has a spare unit without asking any questions. Any questions? Hey Boss!

Panhandle Pete

INSTRUMENTS and AUTOMATION News

Principles & Applications 1712 to 1726
Stock Report 1726
New Plants & Mergers ....1731 to 1732
People in the News .....1737 to 1738

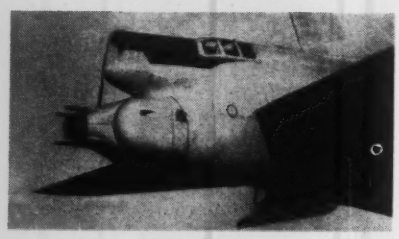
10^6 Bits/Square Inch

SCHENECTADY, N. Y.—An inch-square "honeycomb" developed by a GE scientist will store nearly a million bits of information. There are 250,000 holes in

each square inch of the thin glass sheet. Each hole is etched and filled with metal. Information is written onto one side of the honeycomb by an electron-beam scanning method.

Gunner's "Brain"

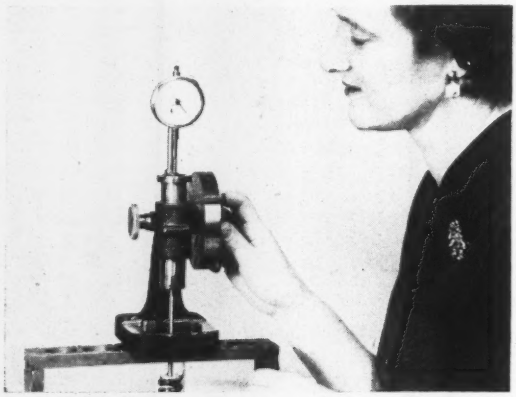
GARDEN CITY, N. Y.—Recognizing the need for weapons-systems changes for American aircraft because of high speed of jet bombers and supersonic fighters, the U. S. Air Force commissioned American Bosch Arma Corp. to develop an electronic brain that lessens



the number of gunners needed in a plane but increases the life expectancy of those that are needed. Sensing elements include radar or optical gunsight to calculate range and position, and gyroscopic devices to sense and correct for angular motion. Integrated systems within the defense system include radar, power, pneumatic, hydraulic, optical, computing, control and gun feed. The system's weight, including gunner and his gear, is comparably less than the manual defensive armament of either the smaller B-17 or B-24 bombers.

Plastics Springs

WASHINGTON, D. C.—Polymeric materials, such a plastics and rubbers, have a number of inherent advan tages for use in springs for special purposes. They ar nonmagnetic, they have low electrical and thermal con ductivity, and they have high corrosion resistance. Unti



now plastic springs have been used little because suitable techniques for their manufacture have been lacking. A practical procedure for mass-producing them now has been developed by the National Bureau of Standards.

The plastic springs are molded by drawing resin-soaked glass fibers through vinyl copolymer tubing and wrapping the loaded tubing in a helix around a mandrel. After curing in an air-circulating oven, the tubing is removed, leaving a solid plastic spring reinforced with glass fibers.

Of the resins studied, the most promising were epoxides and polyesters. The best results were obtained with an epoxy resin cured with m-phenylenediamine. Springs made of this material had torsional moduli of rigidity of the order of 1.0×10^6 psi.

The mechanical and thermal properties of the plastic springs can be varied widely by proper choice of materials and dimensions. Under a load of 25 pounds, 100 of the epoxy-resin springs tested had an average deflection of 0.53 inch with a standard deviation of 0.05 inch.

R-F Power Standards

WASHINGTON, D. C.—As part of a program of r-f power-standards development at the National Bureau of Standards, an improved rf-power-measuring bridge has been designed and built by P. A. Hudson, L. S. Berry, and others of the High Frequency Electrical Standards Section at the NBS Boulder Laboratories. Using only one thermistor, the bridge combines simplicity of operation with greater accuracy over a wide range.

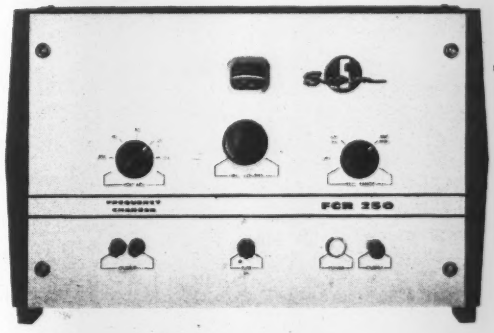
NOW-PORTABLE
400 cycle power

This new frequency changer makes it possible to provide well regulated 400 cycle power conveniently and quickly. This unit, Model FCR 250, is extremely useful in a wide variety of applications including testing, production, airborne frequency control, computers, missile guidance system testing, and in practically any application where the use of 400 cycle power is advantageous.

Model FCR 250 is only one of a complete line of frequency changers available from Sorensen . . . the authority on controlled power for research and industry. Write for complete information.

ELECTRICAL CHARACTERISTICS

Input	105-125 VAC, 1 phase, 50-65 cycles
Output voltage	115 VAC, adjustable 105-125V
Output Frequency	320-1000 cps in two ranges
Voltage regulation	±1%
Frequency regulation	±1% (±0.01% with auxiliary frequency standard fixed at 400 cycles)
Load range	0-250 VA



MODEL FCR 250

SORENSEN & COMPANY, INC. Sorensen STAMFORD • CONN.

For more information circle 13 on inquiry card.

a big line of SMALL packless valves

Packless valves are designed for tough applications, like critical high vacuums, corrosive or dangerous fluids and high temperatures. Our experience with these problems has helped us to design a packless valve line broad enough to suit many of these applications. As evidence may we present:

The 431 Series – a greatly improved version of the Hoke brass bellows needle valve offering extended, leak-tight service life . . . suitable for sampling systems and analysis equipment—bronze bellows, stainless steel (blunt or vee) spindle in ⅛″ and ¼″ pipe sizes.

The 480 Series – Globe or angle valves in brass or monel with phosphor bronze or monel bellows.

The 440 Series – for supercritical applications An all stainless bellows valve with Teflon seat—⅛″ to ½″ pipe sizes. (Both 480 and 440 series have replaceable bellows assemblies.)

The 411 Series – All metal monel diaphragm valves with low internal volume and excellent service life.

For those of you who have special problems, modifications of these valves are available for high temperatures and pressures. You'll find us most receptive to your inquiries.

WE'VE JUST COMPLETED A NEW PACKLESS VALVE BULLETIN THAT WE'D LIKE TO SEND TO YOU. WRITE TO

HOKE

HOKE INCORPORATED

Fluid Control Specialists

231 S. DEAN STREET, ENGLEWOOD, NEW JERSEY

For more information circle **14** on inquiry card.

NEWS—CONTINUED

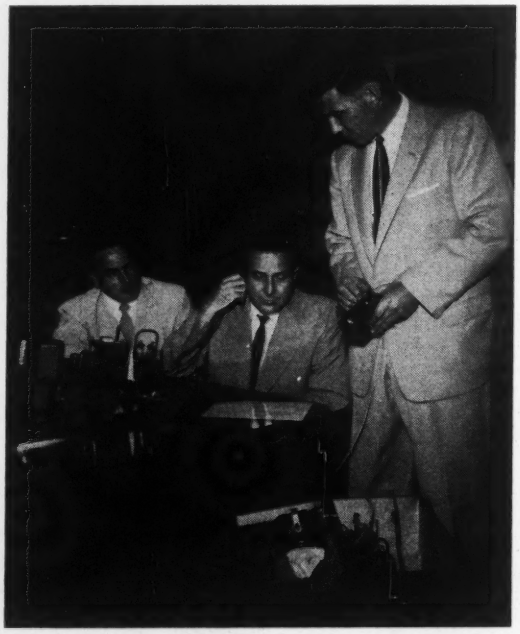
Consumer Research

NEW YORK, N. Y.—Grand Central Station is the site of Ford Motors' consumer research post and "electronic mind reading" station. Auto styling features are pre-

sented to the onlookers who react by moving rating controls expressing approval or disapproval. A specially designed Minneapolis-Honeywell electronic recorder picks up individual ratings, integrates them and displays "average" opinion.

On-The-Spot Automation Demonstration

NEW YORK, N. Y.—Hammarlund Mfg. Co., has equipped its field representatives with valise-like chests



containing COC (Centralized Operation Control) equipment for on-the-spot demonstrations of remote control of distant equipment from the prospective buyer's office.

Here's The Most Versatile Pilot Ever Offered!

BS&B Universal Control Pilot With Type 73-26 Instrument Air Regulator.

It's The New BS&B Universal Control Pilot

For . . . ● Temperature Control ● Pressure Control ● Liquid Level Control

FEATURES

- ✓ **Linear Response.**
- ✓ **Factory Calibration.**
- ✓ **Excellent Frequency Response.**
- ✓ **Micrometer Adjustment.**
- ✓ **Outstanding Performance Repeatability.**

This trim modern-looking weatherproof aluminum case houses the new BS&B Universal Pilot—one of the simplest, yet most versatile control pilots you've ever seen!

Only 8″ x 8″ x 4″ in size, this pilot offers a wide throttling range and high-low snap-acting settings without additional parts. Feed orifice has a push-button cleanout. All parts in the lower half of the case including the stainless steel power unit, micrometer adjusting nozzle, compensating bellows, proportioning band and gauges are common to all three types of service, and are interchangeable to reduce maintenance cost and inventory. Where regulator is required, the new BS&B 73-26 is provided to furnish a finely filtered supply of air or gas.

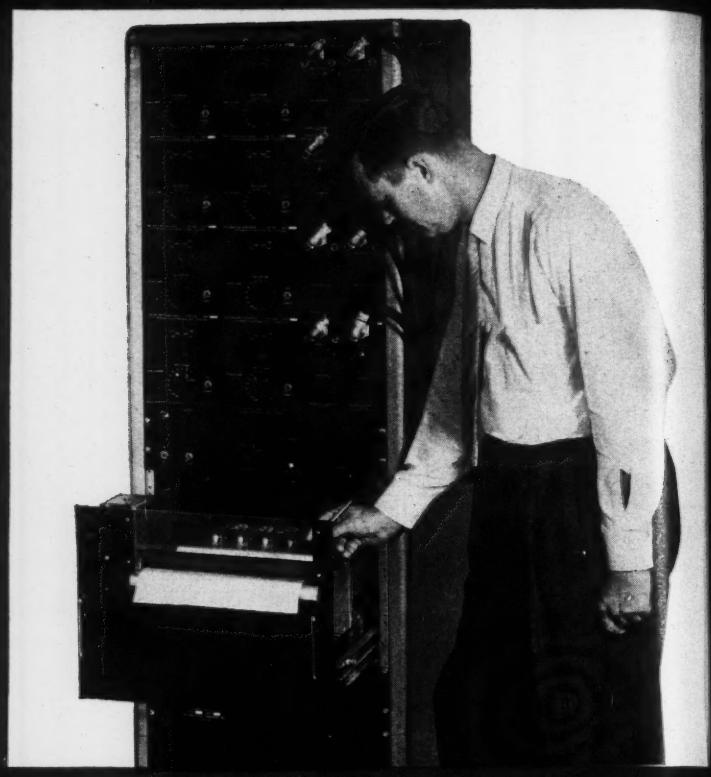
The pilot unit is equally adaptable to wall mounting, remote mounting, yoke or diaphragm mounting, or flush instrument board mounting. An unusual feature, designed for your convenience, is the double-hinged door which opens from either side!

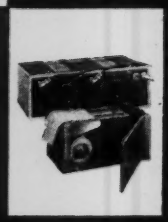
For Full Details On The BS&B Universal Pilot, Contact Your BS&B Representative Or Write To . . .

EFFICIENCY
OVER 60 YEARS
BS&B
RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.
Controls Division, Dept. 4-V9
7500 East 12th Street • Kansas City 26, Missouri

For more information circle **15** on inquiry card.



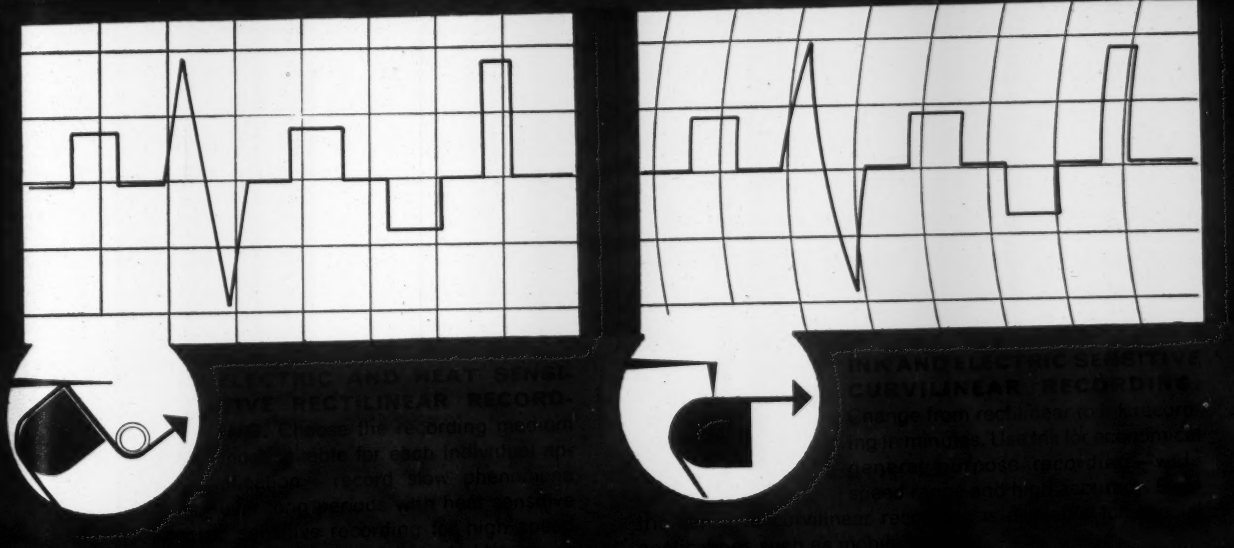


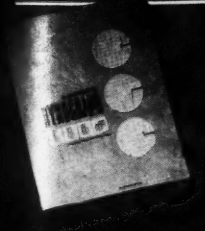
THE OFFNER

DYNOGRAPH

DIRECT WRITING OSCILLOGRAPH RECORDS

unequalled for versatility and performance





Splitting

FOR ACCURATE MEASUREMENT OF

STANDARD ELECTRIC TIME COMPANY
Springfield 2, Massachusetts

SINCE 1884

THE STANDARD PRECISION TIMER
is the indispensable STOP Watch in laboratory and test cell, on experimental nuclear projects, precision production, check and final inspection. Many important applications in almost every industrial plant and research laboratory.

For more information circle **17** on inquiry card.

Split Seconds

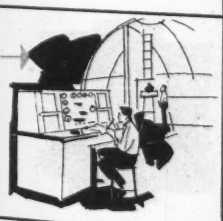
ELAPSED TIME . . . AS CLOSE AS 0.001 OF A SECOND

PRACTICALLY ALL Representative Manufacturing, Processing and Research Plants *USE* STANDARD PRECISION TIMERS

At one of the world's largest automotive manufacturers — timing test action in automatic transmission research.

It is our frank belief that literally hundreds of concerns have not yet scratched the surface of usefulness to which Standard Precision Timers can be put to work in their plants.

For Glenn L. Martin Co.'s Gunnery Trainer — in 12-channel Playback System designed by Cook Research Laboratories.

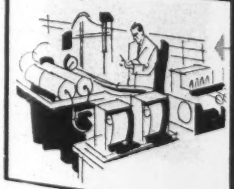


At Eastman Kodak Co. — timing photo cell controlled exposures in automatic photo printing machine.

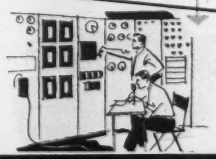
At Yucca Pass, Nevada Proving Grounds — helping maintain split-second control of atomic bomb tests.

At General Electric Co. — Trumbull Division — measuring operating time of circuit breakers.

In Bell Telephone offices throughout the U. S. — timing elements required to complete telephone connections.



At Bendix — Westinghouse Research Dept. laboratories — measuring brake application and release time to 1/100th of a second.



At American Brass Co. — indicating metallurgical analysis in Direct Reading Spectroscope developed by Baird Associates.

Model	Scale Divisions	Totalizes	Accuracy
S-100	1 5 sec.	6000 sec.	±.1 sec.
S-60	1 5 sec.	60 min.	±.1 sec.
SM-60	1 100 min.	60 min.	±.002 min.
S-10	1 10 sec.	1000 sec.	±.02 sec.
S-6	1 1000 min.	10 min.	±.0002 min.
S-1	1 100 sec.	60 sec.	±.01 sec.
MST	1 1000 sec.	360 sec.	±.001 sec.
MST-500	1 1000 sec.	30 sec.	±.002 sec.

World's most accurate and rugged time measuring instrument. Built in many different and advanced designs to meet practically every need of precision time measurement. Requires minimum maintenance.

Synchronous motor drive. Electric clutch controlled by manual switch, automatic switch or output of electronic tubes. Manual or electric zero reset.

SEND TODAY for Bulletin #198 describing entire line with partial list of thousands of customers, and summary of some of the most frequent (and some of the most unusual) ways they use STANDARD ELECTRIC TIMERS.

We suggest you check your requirements for Standard Timers and other products today. Your order or inquiry will receive prompt attention.

The STANDARD ELECTRIC TIME Co.
93 Logan St., Springfield 2, Mass.

Please send Bulletin 198 describing your line of instruments for measuring elapsed time as close as 0.001 seconds.

Name.....*Title*.....

Firm.....

Address.....

.....

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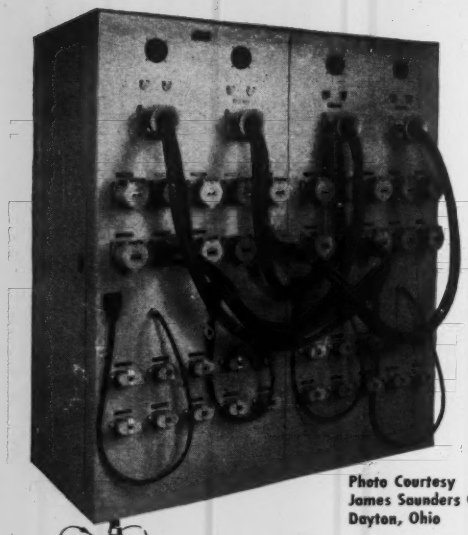


Photo Courtesy
James Saunders Co.
Dayton, Ohio

BETTER AUTOMATION
REQUIRES BETTER
Electrical Connectors

Downtime is Automation's most relentless enemy. That's the reason every link in a production chain should be carefully selected. Electrical Connectors in power feeder and control circuits, for example, must do more than merely meet electrical specifications. To provide dependable long-lasting service they must also be highly resistant to damage by oils, acids and rough handling . . . and when connected, must not permit moisture or dust to contaminate their contacts. JOY one-piece Neoprene insulated connectors meet all these requirements and they're available in a wide variety of single and multiple-contact designs. Want more facts? Ask and we'll mail them . . .
Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa. *In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario.*

and
JOY
Connectors are better Electrical Connectors

OIL SEALED — One-piece molded cable/connector assembly protects conductors from oil and other external impurities.

DISTORTION-PROOF — JOY Connectors cannot crack, will not shatter and are practically impossible to knock out of shape.

MOISTURE-TIGHT — Water cannot penetrate one-piece, molded body and face seals protect contacts when connectors are engaged.

CD 156.1

JOY
SOURCE OF INDUSTRY'S FAVORITE ELECTRICAL CONNECTORS SINCE '28

For more information circle **18** on inquiry card.

Glass Scales Etching

WASHINGTON, D. C.—Information on a number of techniques for producing precise etched glass scales has recently been made available by the National Bureau of

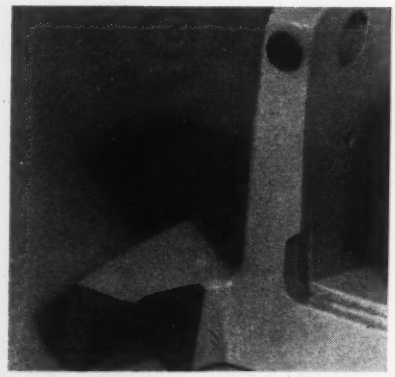
Standards. Methods for domestic manufacture of high-precision graduated glass circles and reticules for theodolites were developed by Raymond Davis and Chester C. Pope of the Bureau staff. Techniques can be applied to manufacture of glass scales for dividing heads, indexing tables, cam-rise gages, etc.

Control Systems Concepts

NEW YORK, N. Y.—New York Sec., AIEE, Power & Industrial Div., will sponsor a study group on "New Concepts in Control Systems" from October 3 to December 19. The group will meet on successive Wednesday evenings 6:30 to 8:30 at the Westinghouse Auditorium, 40 Wall St., N. Y.

Epoxy Coating

NEW YORK, N. Y.—In an effort to find a coating for doctors' instruments that would not wear thin and chip after a few years use, American Optical Instruments Division researchers hit upon an Epon resin-based coat-

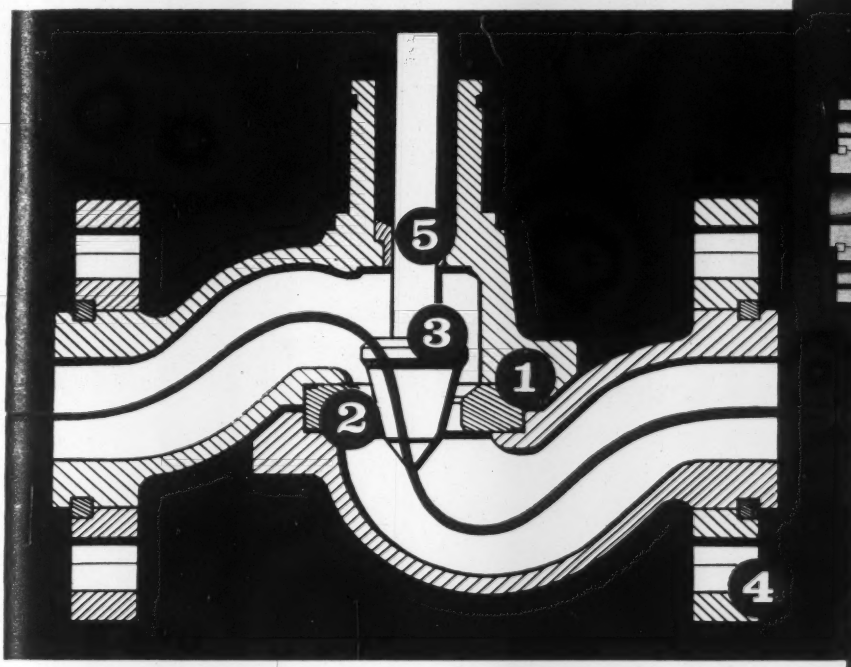


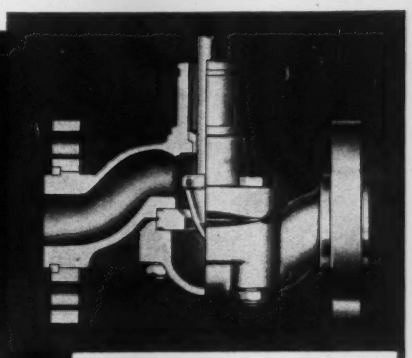
ing applied by hot-spray. The coating is scuff-proof, chip proof and chemically inert. Illustration shows adhesion of coating when base casting was struck with a hammer. Casting broke, but coating did not flake off.

ANNIN BODY DESIGN

...THE SOUNDEST APPROACH TO TROUBLE-FREE FLUID CONTROL

Reduces body turbulence and erosion • Longer seat ring life—retains tight closure • High lift in all sizes for better control—greater rangeability • Fewer parts—simplified and much lower maintenance.

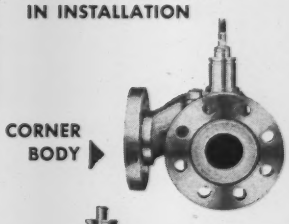


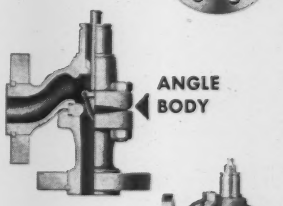


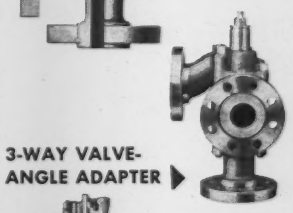
GLOBE BODY ▲

The basic form of all Annin Valves. Reduces number of parts 50 to 75%, lowers initial costs, saves on parts inventory and maintenance.

OTHER BODY DESIGNS PROVIDE FLEXIBILITY IN INSTALLATION







Annin Valves are the answer to the complex fluid control problems common in the process industries—Chemical, Petroleum, Paper, Steam, Power Plants, and many others. Today, Annin Valves are recognized by control engineers and valve designers as the outstanding valve development of the past twenty-five years for the control of hot, cold, erosive, or viscous liquids.

• • •

Annin's complete line of control valves will be on display in booths 1408 and 1409, 11th Annual Instrument-Automation Conference and Exhibit.

1 BODY. Single seat split body construction eliminates pockets and shoulders... reduces erosion.

2 SEAT RING. The body flanges retain seat in perfect alignment with valve plug.

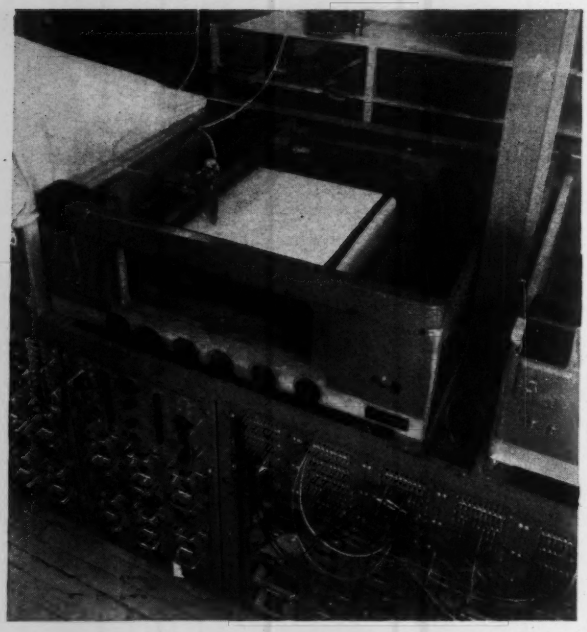
3 VALVE PLUG AND STEM. Valve plugs are contoured to provide either linear, percentage, or semi-throttle characteristics... reduce turbulence, wire drawing, plug vibration and noise.

4 SEPARABLE FLANGES. Can be interchanged at will. Carbon steel flanges can be mounted on alloy bodies for economy.

5 PLUG GUIDE. Hard metal guides of close tolerances can be inserted through stuffing box without resorting to threads, welding, pressing or staking.

ANNIN THE ANNIN COMPANY
6570 EAST TELEGRAPH ROAD, LOS ANGELES 22, CALIFORNIA
Control VALVES

For more information circle **19** on inquiry card.



MIT Function Generator

plots curves on a special Bristol strip chart

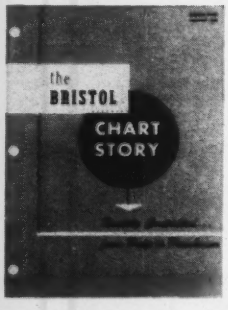
The strip chart above was designed and printed by Bristol especially for the MIT function generator.

It's one of hundreds of special strip and circular charts Bristol turns out each year to instrument builder specifications.

Why Bristol? Several reasons: We've been printing precision instrument charts for over 65 years, for one thing. We're familiar with instrumentation problems, for another. And, already one of the largest chart printers in the country, we've recently expanded our production facilities and engineering service.

What does this mean to you? It means that at Bristol you can get circular charts up to 12 inches in diameter—strip charts up to 29⅝ inches across. You can get charts for all kinds of special instruments—research, industrial, test, analytical, scientific, laboratory and pilot plant instruments and computors, to name a few. You can get charts printed on wax-coated, heat-sensitive, chemically-coated, electrically-sensitive or other special papers.

What's more, it will pay you to call on Bristol's chart service when your recorder is in the design stage. Put our long experience in designing both instruments and charts to work for you. Write the Bristol Company, 154 Bristol Road, Waterbury 20, Conn.



FREE BULLETIN Y1904 tells how Bristol Charts are made. Write for your copy.

6.17

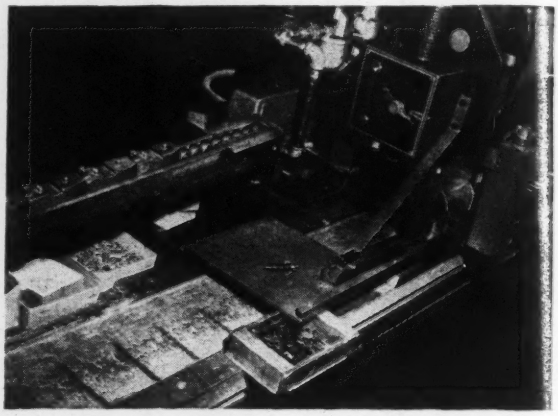
BRISTOL *Points the Way in Human-Engineered Instrumentation*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **20** on inquiry card.

Compressed Air Applications at Astatic

CONNEAUT, OHIO—Special applications of compressed air power at The Astatic Corp., Conneaut, O., have been increased because of notable savings in time and labor costs in the manufacturing of microphones, phonograph pickups, recording heads and accessories.



Many special applications of compressed air have been made via simple combinations of various sizes of air cylinders, piston power, air motors, filters, pressure regulators and lubricators. Many manual operations have been done away with. An important safety factor is designed into special air-powered machines with the inclusion of a one-inch air cylinder that operates a microswitch that keeps current off until air power is turned on for the particular operation.

Examples involve staking spacers on the back end of cartridge housings (previously done on a hand arbor press), a pivot staking machine, notching of the back end of a cartridge housing, clamping a shaft-and-tube-riveting job in a light hydraulic press, and even final assembly, as shown in the illustration. The timer shown holds the press down for ½ second so that eyelets are set completely.

News Bits

GENERAL ELECTRIC CO. took the first step in a long-range program for expanding advanced-engineering facilities in the computer field with the establishment of a computer laboratory at Menlo Park, Cal. GE Electronics Lab reports a compatible system that now makes it possible to economically combine slow and fast scan television.

AEC has released 55 patents for public use and will grant non-exclusive, royalty-free licenses on listed patents as part of the program to make non-secret technological information available to industry.

HIGH VOLTAGE ENGINEERING CORP. described a new model 2-million-volt Van de Graaff particle accelerator for cancer therapy before delegates to the Eighth International Congress of Radiology.

THE INSTRUMENTS PUBLISHING COMPANY

announces publication of

MILITARY AUTOMATION

. . . to cover instrumentation and control systems, devices, and components which have applicability in equipment designed primarily for use by the Armed Services.

First regular issue: February 1957

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Complete information must be given. TYPE OR PRINT LEGIBLY, please.

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Check which ONE of the following best describes YOUR function (NOT your organization's) in the field of military electronics and controls . . .

DESIGN ☐ DEVELOPMENT ☐ RESEARCH ☐ MANUFACTURE ☐
SPECIFICATION ☐ PURCHASE ☐ INSTALLATION ☐ MAINTENANCE ☐

Please sign your name here and date here

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Department..... Organization.....

Address.....

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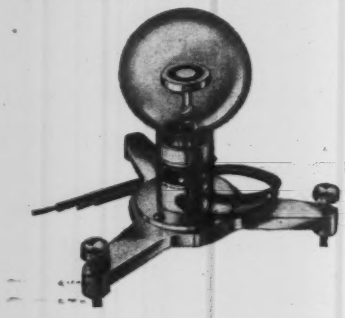
NO CHARGE AND NO OBLIGATION

EPLAB

PYRHELIOMETER
For the Measurement of
SOLAR RADIATION



Eppley Pyrheliometers are used for solar radiation measurements at ninety-eight weather stations in the continental United States, Canada, Alaska, Greenland, Iceland, Caribbean Sea, and the Pacific Ocean. Sixty-two of these stations are under the direction of the United States Weather Bureau.

The Eppley Pyrheliometer was adopted as standard equipment by the Weather Bureau after considerable experimentation. It was found to be the best instrument so far tested by the Bureau.

Used in conjunction with a suitable recorder, the Eppley Pyrheliometer will provide an accurate and reliable record of total solar and sky radiation on a horizontal surface.

Bulletin No. 2 on Request

THE EPPLEY LABORATORY, INC.

Scientific Instruments

2 Sheffield Ave.
Newport, Rhode Island U.S.A.

For more information circle **21** on inquiry card.

NEWS —CONTINUED

BAILEY METER CO. has adapted a "Building Block Method" to a new line of multi-purpose instruments and controls which will permit users to select instruments to build their own special-purpose systems.

RAMO-WOOLDRIDGE CORPORATION'S Dr. Eugene M. Grabbe, a senior member of the Computer Systems Div., presented a talk on "Computers and Automation" at the International Congress on Automation, Conservatoire National des Arts et Metiers, Paris, France.

TELEREGISTER CORP. has made the Toronto Stock Exchange the first stock and commodity market in the world to be electronically automated. The system provides brokerage offices with a display panel which instantly and automatically displays latest bid and asked prices on any 50 stocks the broker may select. Toronto's trading by far exceeds all other markets in the world, including New York.

Teleregister Stock System

Air Traffic Display

STROMBERG-CARLSON CO. has begun production of an electronic display device designed to aid in solution of air traffic control. Device is commercial adaptation of "Charactron" shaped-beam tube used in SAGE system of military aircraft surveillance.

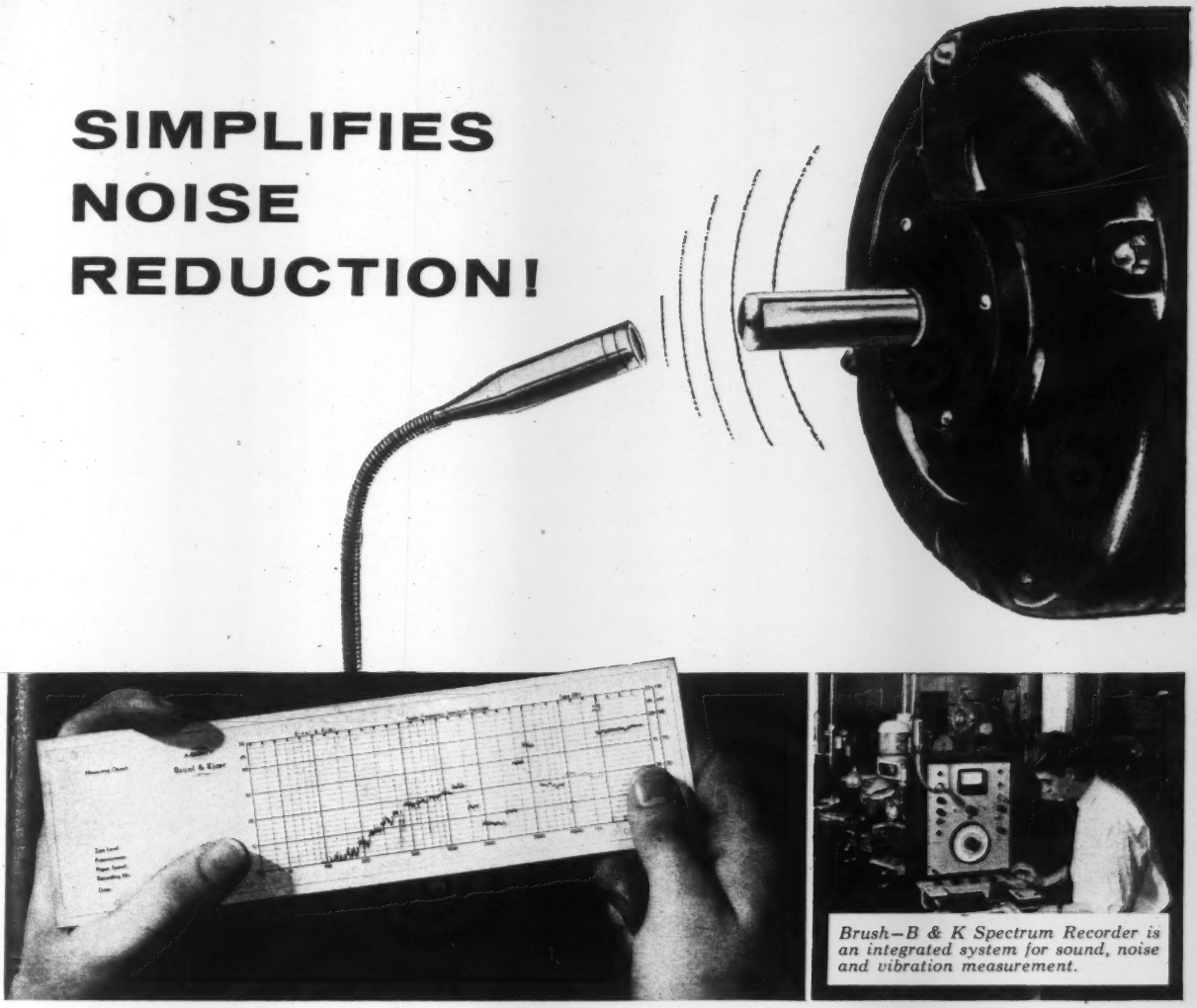
GENERAL ELECTRIC'S Instrument Department will sponsor a course Sept. 24-28, Portsmouth, N. H., featuring industrial applications of spectrophotometry and colorimetry.

MASSACHUSETTS INSTITUTE of TECHNOLOGY played host to nearly 200 prominent scientists from the U. S. and abroad at the week-long meeting of the International Commission of Optics. Subjects covered included types of microscope and measuring devices, films and filters, and nuclear optics.

WAYNE STATE UNIVERSITY'S COMPUTATION LABORATORY held three weekly courses from July 23 to August 11. Subjects included: Automatic Computers, Their Application and Evaluation; Electronic Data Processing in Business and Government; and Application of Computers to Engineering, Science and Industry.

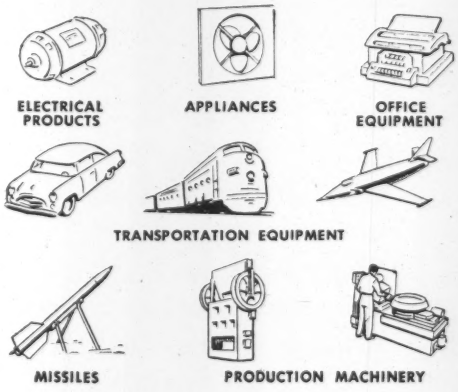
PENNSYLVANIA STATE UNIVERSITY held a short course on June 10 to 15 on automation for small businesses. Subjects included: What Needs To Be Done To Automate Production and How To Get Started.

SIMPLIFIES NOISE REDUCTION!



Brush—B & K Spectrum Recorder is an integrated system for sound, noise and vibration measurement.

Now you can obtain complete frequency-amplitude noise records in 21 seconds



More and more, product quality is being judged by quietness of operation. The first step in noise reduction is to *get the facts.* Here, instrumentation offered by Brush can simplify and speed your solution of design problems.

The Brush—B & K Spectrum Recorder is a complete system which *automatically* scans and records all sounds from 14 cycles to 36,000 cycles per second. Measurements are made in one-third octave steps, with both frequency and amplitude in each step recorded. A complete test takes only seconds—thus the equipment can serve not only in development studies but in production-line tests.

Brush offers a complete line of instrumentation to simplify your noise, vibration and strain measurements. Call your Brush Representative now for application assistance or write for a brochure.

For complete information write Dept. A-99

BRUSH ELECTRONICS COMPANY

3405 Perkins Avenue, Cleveland 14, Ohio

BRUSH 6 ELECTRONICS

DIVISION OF CLEVITE CORPORATION

For more information circle **22** on inquiry card.

American Institute of Electrical Engineers

in cooperation with

American Physical Society

American Institute of Mining, Metallurgical and Petroleum Engineers

and the Institute of Radio Engineers

present the

SECOND CONFERENCE and EXHIBIT on MAGNETISM and MAGNETIC MATERIALS

Hotel Statler, Boston, Massachusetts

OCTOBER 16-18, 1956

► Eight Sessions will include approximately 75 technical papers:

MAGNETIC ANISTROPHY
PERMANENT MAGNETS & FINE PARTICLES
MAGNETISM & PHYSICAL METALLURGY
LOSSES IN SOFT MAGNETIC MATERIALS
FERRITES
HIGH FREQUENCY PHENOMENA
SWITCHING DEVICES & MAGNETIC AMPLIFIERS
APPARATUS & DESIGN

► Exhibitors will include:

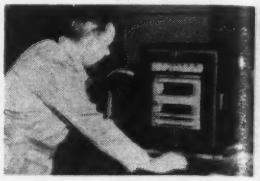
THE ARNOLD ENGINEERING COMPANY
BELL TELEPHONE LABORATORIES, INC.
THE CARPENTER STEEL COMPANY
CRUCIBLE STEEL COMPANY
GENERAL ELECTRIC, METALLURICAL PRODS. DEPT.
GENERAL ELECTRIC RESEARCH LABS.
GENERAL MAGNETIC CORPORATION
THE INDIANA STEEL PRODUCTS CO.
INSTRUMENTS PUBLISHING COMPANY
MAGNETIC METALS COMPANY
MAGNETICS, INC.
RADIO FRENQUENCY LABS.
RESE ENGINEERING, INC.
WESTINGHOUSE ELECTRIC CORP.

for advance registration or information

write: **T. O. PAINE, Local Conference Chairman**
General Electric Co., West Lynn, Mass.

THE WALKIRT CO. recently installed preset counters for Arlington Citrus Growers Association Plant to automatically control lemon boxing. Initial reports indicate the counters will afford 99% saving in labor costs, not to mention elimination of waste due to overstuffing.

Walkirt Counters



L & N Radiation Pyrometer

LEEDS & NORTHRUP CO. radiation pyrometer guides critical induction heating of rare metals (costing as much as $20/lb) at Super Alloy Forge, Inc. Parts are heated rapidly by induction to temperatures in range of 2400°F and often must be within 10F° of required working temperature for proper forging.

Stock Report

The following prices and price ranges are supplied by Bache & Co., 36 Wall Street, New York 5, New York.

New York Stock Exchange:

Security	Price Range for 1956 Thru July 31 High	Low	As of July 31 Last
Aeroquip	15 3/8	11 7/8	14 3/8
American Chain & Cable	51 7/8	38 1/2	49 1/8
American Mach. & F.	32 1/8	24 1/8	28 3/8
American Mach. & M.	40 3/4	35 1/8	38 3/4
American Optical	40 3/4	34 1/2	36 1/4
Beckman Instruments	37 5/8	25 1/8	36 1/2
Bell & Howell	45 1/2	28 1/4	40 3/4
Bendix Aviation	63	48 1/2	53 3/4
Bulova Watch	23	20 1/4	21 1/4
Burroughs	44 3/4	28 1/2	42 7/8
Clevite	24 1/4	18	19
Dobeckman	39 1/4	31 1/4	32
Gamewell	32 3/8	25 5/8	32 1/4
General Inst.	10 1/8	7 3/8	7 5/8
General Prec.	53 1/2	37 1/2	43 1/4
General Time	33 1/8	29 1/2	32
Hamilton Watch	25 3/4	19	25 1/2
International Business Mach.	523	400	515
Minneapolis-Hon.	90 1/2	58	87 5/8
National Cash Reg.	59	34 1/8	55 3/4
Radio Corp.	50 3/8	41 1/8	42 3/4
Raytheon	19 1/2	13	13 7/8
Robertshaw-F.	28 3/8	21 1/2	23 3/8
Sangamo Electric	37 1/2	29 1/2	35 3/4
Sperry Rand	29 1/8	23 5/8	26 3/4
Square D	82	51 1/2	79 1/4
Starrett, L. S.	56 1/2	43 3/4	54 - 54 5/8 (1)
Sylvania Electric	55 7/8	42	53
Telautograph	15 1/4	11	13 1/2
Texas Inst.	15 1/8	11 5/8	13 1/2
Underwood	44	28 3/4	30 1/4

(1) Bid - Asked price, no sale.

American Stock Exchange:

Security	Price Range for 1956 Thru July 31 High	Low	As of July 31 Last
Air Assoc.	13 1/2	9	9 7/8 - 10 (1)
American Meter	41	33	35 7/8
Benrus Watch	10 3/8	8 1/4	8 1/4
Breeze Corp.	9 1/8	6 1/8	6 1/4
Consolidated Electrodynamics	32 1/2	21	32
DuMont Labs.	10	5 3/4	6 1/2
Fairchild Camera & Instr.	25 7/8	19 1/2	24 3/8
Int'l Resistance	8 1/4	5 5/8	5 7/8
Lear Inc.	10 1/4	7 1/2	7 3/4
Nat'l Res. Corp.	29 3/4	17 7/8	22 7/8
Neptune Meter	36	28 3/8	35 1/4
New Haven Clock	2 1/2	1 1/2	1 1/2 - 1 3/4 (1)
Norden-Ketay	14 7/8	9 5/8	9 7/8
Pneumatic Scale	28 1/4	24	25 1/4
Servomechanisms	10 3/8	8 1/4	9 7/8
Wallace & Tiernan	22 1/2	19 1/2	20 3/8
Waltham Watch	3	1 1/4	1 1/2

(1) Bid - Asked price, no sale.

Circle **23** on inquiry card. ⟶

Honeywell
Control savings can start
before your process goes on stream
H
HONEYWELL
– and here's how –

Design your instrumentation

for simplest installation, startup,

-with *Tel-O-Set* instruments

The exclusive features designed into *Tel-O-Set* miniature instruments save you time, trouble and money . . , from the instant these instruments are installed on your control panels.

Easy installation. The indicating and recording chassis is a complete assembly that can be supplied separate from the case. Since the case contains the valve pressure gage and pressure regulator, you can install it in the panel, make complete piping connections . . . and then insert the instrument chassis later, at startup.

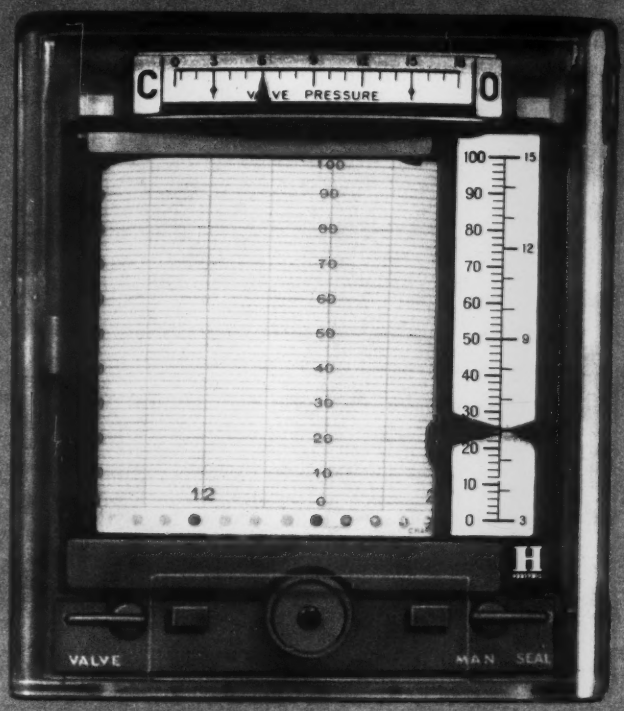
Foolproof startup. Because it can be shipped separately, the chassis is protected against dirt and damage until it is ready to begin service. Air lines can be checked, control valves stroked and final inspection made *before* the chassis and controller are installed.

Serviced in seconds. Down-time for instrument maintenance is eliminated, for a complete chassis can be replaced in just a few seconds. There is no loss of control during replacement . . . no disturbance to electrical connections. To adjust zero and span, or to inspect parts, you can partly withdraw the chassis from the case, without interrupting operation.

Tel-O-Set instruments can handle a broad range of temperature, pressure, flow and liquid level applications. They work with any type of pneumatic force-balance controller. They are sensitive and accurate . . . have true linear calibration . . . respond instantly to changes in measured variables. For a discussion of how you can use them profitably, call your local Honeywell sales engineer . . . he's as near as your phone.

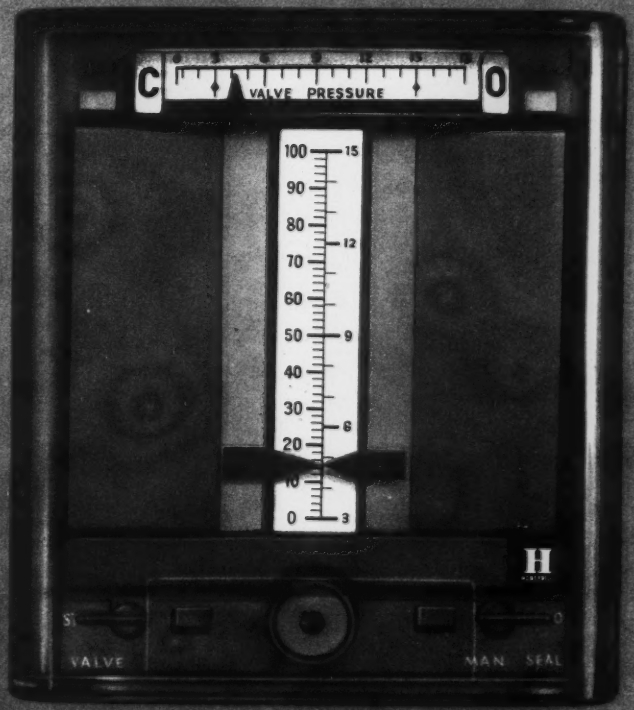
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

service

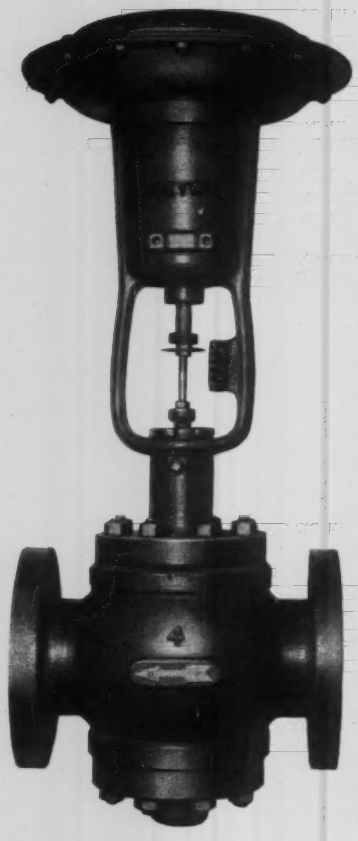


HONEYWELL

Both the *Tel-O-Set* indicator and recorder have vertical indicating scales on which large, opposing pointers clearly show measured value and set point. The control knob and transfer switches are located near the bottom of the case, where they can be manipulated without the operator's hand obscuring the view of the pointer and scale.



● **REFERENCE DATA:**
Write for Bulletin 7202



Newest HONEYWELL Series 800 Diaphragm Control Valve

for dependable service in the "working end" of your control loop

Here's the high-quality, pneumatic valve specifically designed for modern process control . . . ideal partner for *Tel-O-Set* instruments.

The Series 800 valve embodies advanced design features that assure sensitivity, response and reproducibility . . . with minimum maintenance.

- ***Pressed steel diaphragm cases*** treated to resist corrosion.
- ***Rigid cast iron yoke*** protects stem alignment.
- ***Bolted packing gland*** assures easy adjustment, maximum safety.
- ***Interchangeable 3-15 and 6-30 psi springs.***
- ***Top and bottom guiding*** for positive control action.
- ***Oilite guide*** on actuator stem reduces friction.

The new Series 800 line includes a wide variety of actuators, body types, sizes, materials and auxiliary equipment. For complete information write to: MINNEAPOLIS-HONEYWELL REGULATOR CO., *Valve Division*, Philadelphia 23, Pa.

SERVICE . . . where and when you need it

Service is the big extra you get with Honeywell instrumentation. Honeywell service begins with your initial plans for control, and follows through long after instruments are installed. It covers these important areas:

Application engineering, by a staff experienced in your particular processes, of complete systems custom-fitted to your plant.

Installation and startup assistance, by Honeywell service engineers.

Maintenance engineering, in emergencies or on a periodic service schedule, by factory-trained specialists located near you . . . in the more than 110 Honeywell offices in the United States and Canada.

Quick shipment of parts, from your local Honeywell branch office or from the Parts Depot in Philadelphia.

Training School, maintained by Honeywell as a service to customers, teaches your instrument technicians up-to-date maintenance methods.

Find out how Honeywell service can pay off on your own control applications, by calling your local Honeywell office . . . as near as your phone.

H HONEYWELL

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*,
Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

New Plants and Mergers

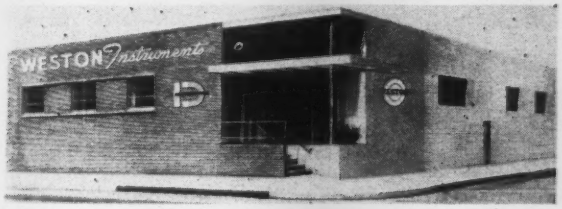
SORENSEN & CO., Stamford, Conn., announces a merger with Beta Electric Corp., New York. *Victor Wouk*

(left), president of Beta, signs agreement with *Marcel Corbat*, Chairman of the Board of Sorensen (center), and *Albert Blanc*, president of Sorensen.

TEXAS INSTRUMENTS INC., Dallas, Texas, announces acquisition of the Wm. I. Mann Co., privately-owned optics firm. TI exchanged 21,100 shares of its common stock on a share-for-share basis for all Mann Co. shares outstanding.

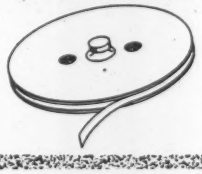
POTTER & BRUMFIELD, INC., Princeton, Ind., announces completion of production facilities expansion to more than 125,000 sq. ft. by construction of a 16,000 sq. ft. building addition in Princeton and leasing of 15,000 sq. ft. in Franklin, Kentucky.

WESTON ELECTRICAL INSTRUMENT CORP., announces opening of a branch sales office and warehouse at 2001 S. Grand Ave., Los Angeles, Calif.



LIBRASCOPE, INC., Commercial Division, Burbank, Calif., announces that Barton Instrument Corp., Los Angeles, will distribute the new Librascope Flow Computer line.

RAYMOND ROSEN ENGINEERING PRODUCTS, INC., Philadelphia, Pa., announces change of name to Tele-Dynamics Inc.



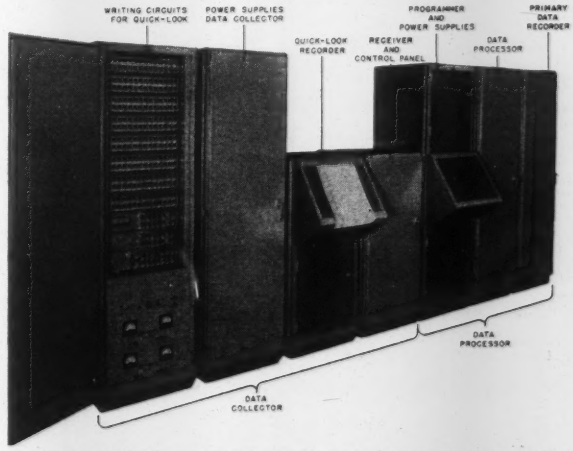
DIGITAL COMPUTER DATA PROCESSING

This digital system provides:

- **Magnetic tape data storage**
- **Quick-Look with timing**
- **Accurate detail data plotting**
- **Automatic programming**
- **Digital tapes compatible with your computer**

Write for Bulletin R-1047-30

Personnel Inquiries Invited

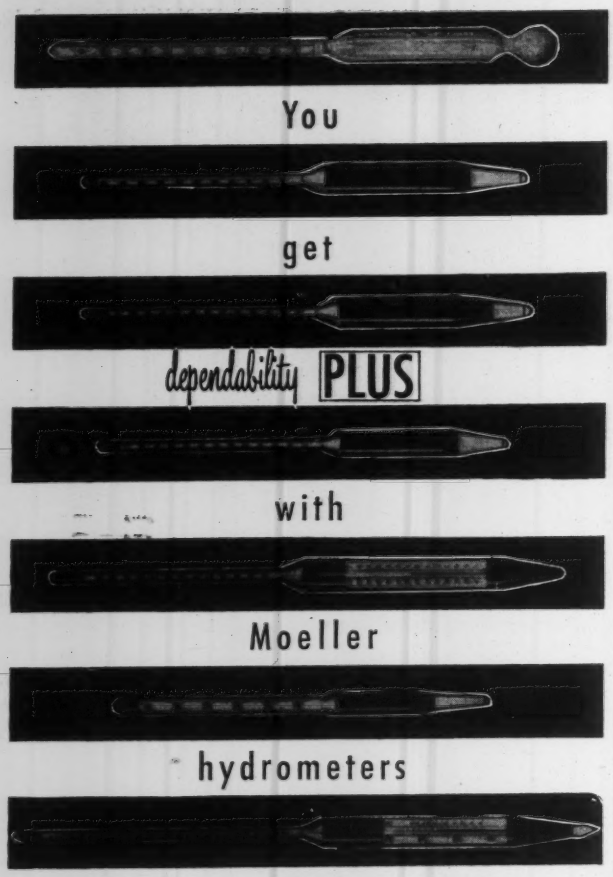


RADIATION Inc. Melbourne, Fla. Orlando, Fla.

Electronics • Avionics • Instrumentation

For more information circle **24** on inquiry card.

For more information circle **23** on inquiry card.



because the design and manufacture of instruments that measure the density of liquids has been our business since 1867

Moeller Hydrometers are stocked in all standard scales—Brix, Twaddle, Ballings, A.P.I., etc., in plain form or combined with thermometers. *Mail coupon for the Moeller Hydrometer Catalog, today!*

MOELLER INSTRUMENT COMPANY
132nd ST. and 89th AVE.
RICHMOND HILL 18, N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send me Moeller Catalog No. 800 on Hydrometers.

NAME .....

FIRM .....

ADDRESS .....

CITY ..... ZONE ..... STATE .....

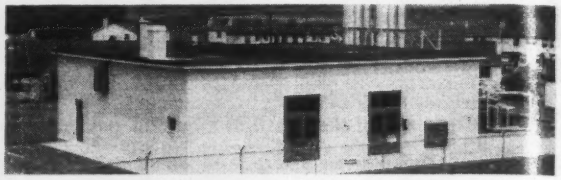
For more information circle **25** on inquiry card.

PLANTS—CONTINUED

FISCHER & PORTER CO., Hatboro, Pa., announces purchase of the Andrews Glass Co., Inc., Vineland, N. J.

CONSOLIDATED ELECTRODYNAMICS CORP., Pasadena, Calif., announces that sales and earnings for the first six months of 1956 provided a 92% increase in net earnings compared to the same period in 1955.

FISCHER & PORTER CO., Hatboro, Pa., announces dedication of a new fluids calibration laboratory called the



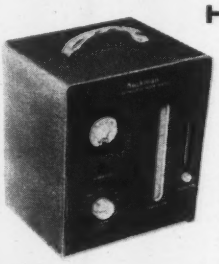
"Allan P. Colburn Memorial Flow Laboratory" in memory of one of the pioneers in fluids engineering research.

OPTO-METRIC TOOLS, INC., Staten Island, N. Y., a company newly organized by Fritz Koenig, announces they will specialize in domestic and foreign optical measuring tools with a nationwide sales and service organization.

ELECTRIC REGULATOR CORP., Norwalk, Conn., announces acquisition from Texas Instruments, Inc., Dallas, Texas, of the regulator business formerly handled by the Burlington Instrument Co., Burlington, Iowa.

Looking for one part of water in a million parts of gas?

BECKMAN ELECTROLYTIC HYGROMETER



Where the presence of minute amounts of water is critical . . . in the control of corrosion, product purity, and process efficiency . . . the ideal instrument is the new Beckman Electrolytic Hygrometer. The Hygrometer continuously and automatically measures water vapor in the 0-1000 ppm range. When moisture content rises above a preset limit in a gas stream, it will automatically set off an alarm. *No one has to watch it!* It gives extra-sensitive detection at temperatures up to 100°C. And it can operate a standard mv recorder.
Write Beckman Instruments, Inc., Scientific Instruments Division, Fullerton, California, for Data File N-27-47.

Beckman® / *process instruments*

Our continued growth creates openings for creative engineers. Write for career file #10.

For more information circle **69** on inquiry card.

RIGHT NOW...

Over 100 Epsco high speed reversible voltage-to-digital converters are in operation at over 25 separate commercial and military activities throughout the world.

No other voltage-to-digital conversion equipment presently available anywhere will approach the accuracy, conversion speed, reliability, long term stability, versatility and simplicity of operation of the Epsco Model B DATRAC® . . . regardless of price!

MODEL B DATRAC® FEATURES

ABSOLUTE ACCURACY: ±0.05% of full scale ±½ least significant digit.

CONVERSION SPEED: 44,444 independent V➔D conversions per second for an 11 bit binary code including sign.

RELIABILITY: Proven field service in excess of 5000 hours of continuous operation without maintenance.

LONG TERM STABILITY: Within one least significant digit for life of the equipment.

INPUT (V➔D): ±10 millivolts to ±1000 volts differential or single ended.

OUTPUT (V➔D): Binary or binary coded decimal.

SIMPLICITY OF OPERATION: No operator adjustments. Calibrated automatically to internal standard cell.

GET THE FACTS

Send for your copy of detailed specifications

EPSCO
INCORPORATED

588 Commonwealth Avenue, Boston 15, Massachusetts
West Coast Office: 1722 Westwood Blvd., Los Angeles, Calif.

For more information circle **26** on inquiry card.

BRISTOL'S INSTRUMENTATION

News and information about automatic controlling, recording and telemetering

How instrument men pick a winner!

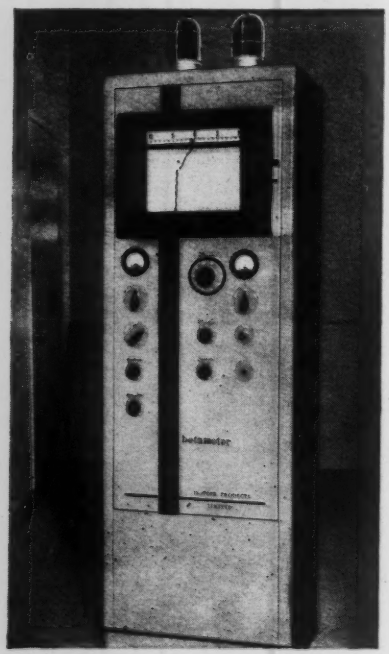
More and more manufacturers are incorporating Bristol's Electronic Dynamaster® potentiometer and precision all-purpose bridge instrument into their own instrument systems. On these pages you'll see a few of its applications—in the measurement, recording and control of any variable that can be translated into an electrical quantity. There are good reasons for this choice of the Dynamaster—whether for plant, laboratory or pilot plant application. Here they are:

1. Continuous standardization eliminates need for dry cells and standardizing mechanism—result: no interruption to control, no dry cells to replace.
2. High accuracy . . . fast operation . . . continuous electronic measurement.
3. Simple in design . . . few moving parts.
4. Easy to use and service . . . little or no maintenance required.
5. Flexible in application.
6. Rugged in construction . . . unaffected by vibration.
7. Plant operating men quickly become familiar with this instrument and like to use it.
8. Versatile for single-pen, two-pen, and multiple record (up to 24 points), with either strip- or round-chart.

ELECTRONIC AND PNEUMATIC CONTROLLERS. Both strip- and round-chart instruments are made in a very wide variety of controllers that meet every control requirement, including:

Electric Control—on-off, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

Pneumatic Control—high-gain (on-off), proportional, proportional with reset, and proportional with reset and derivative.



ISOTOPE PRODUCT'S "Betameter."

Gauges sheets to 0.25 lb. in 3000 sq. ft.

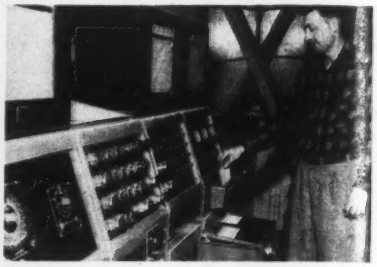
The "Betameter," one of the latest results of modern nuclear instrumentation, was designed and built by Isotope Products of Buffalo, New York, and Oakville, Ontario. It can measure thickness of all continuous sheet materials from tissue paper to 0.070-inch steel. It attains accuracies up to 0.25 pound of material per 3000 square feet.

Beta rays, beamed through the material to be measured, cause electric current flow in a detector. The current, proportional to deviation of the material from the desired thickness, is amplified and recorded, or used for automatic control, by a precision Bristol Dynamaster instrument.

Dynamasters are also used in Isotope Product's "Gammagage" (for measuring heavier materials), "Profiler" (for taking the profile of strip samples), and "Betacoater" (for gauging thickness of coatings).

For more information circle **27** on inquiry card.

Punched-card cement batcher increases accuracy



This novel automation system, installed at Cleveland Builders Supply Corporation's Cleveland, Ohio, plant, was designed to turn out twice as much ready-mixed concrete as the company's similar conventional plants.

The operator merely drops a card, punched with the mixing formula, into the machine and the mixture is ready in a matter of seconds. Ingredients are accurate to 2 pounds as against 25 for a human operator. This results in considerable savings in material and also reduces operator fatigue.

Essential part of the installation are the Bristol Dynamaster recorders that provide permanent records of the output of strain gauges used in the weighing process.

How "No-Batt" bans service interruptions

COMPACT continuous standardization unit takes place of dry cell in this Dynamaster recorder.

All the convenience of a line-operated power supply plus the accuracy and stability of a standard cell—that's what Bristol's "No-Batt" continuous standardization gives the user. There are no dry cells to replace and absolutely no interruptions to service for standardization.

This ingenious development achieves voltage accuracy of 1/10th of 1 per cent with an estimated standard cell life of 5 to 7 years.

All Dynamaster models may be equipped with this feature for completely uninterrupted recording, measurement or control—and, of course, the more conventional dry-cell and push-button or automatic standardization are still available.

NEWS AND NOTES

instruments from Bristol . . . leaders in human-engineered instrumentation

Greatest analytical development in decade!

Gas chromatography units, with Bristol recorders, speed analysis

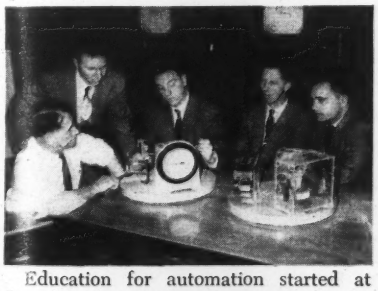
Computing and recording equipment is now aiding automatic qualitative and quantitative analysis of gases and volatile liquids by partition chromatography. Scientists at Gulf Research and Development Co., and Fisher Scientific have built an instrument using a thermostatted chromatographic column to resolve components of each mixture.

As each component emerges from the column, it is detected and a record made on a built-in, accurate high-speed Dynamaster recorder. An automatic integrator simultaneously computes the quantity of component and makes a second record.

Other units which use Dynamaster recorders in this application include Podbielniak's *Chromacon*, Beckman's *Gas Chromatograph*, and Research Equipment Corp.'s *Distillograph*.

Photo courtesy of Fisher Scientific Company.

Professors turn students at Bristol



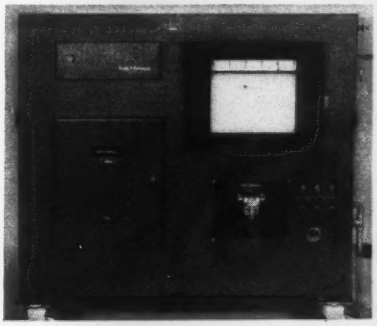
Education for automation started at Bristol back in 1920 with an instrumentation school for our own sales and service engineers. In 1927, we invited our customers' engineers to our school—and in 1949, we opened our first free summer training session (since repeated several times) for professors from engineering schools throughout the country.

Among subjects studied: pressure and vacuum, including liquid level and absolute pressure; telemetering; flow measurements; pyrometers, thermocouples and resistance thermometers; electronic detection; filled thermometer systems and relative humidity; and electrical measurements with voltmeters, ammeters and wattmeters.

Oxygen Analyzer uses Dynamaster recorder

Recording and control of oxygen in gases of all types is the job of this oxygen analyzer, designed and built by Arnold O. Beckman, Inc., South Pasadena, Cal.

The operating principle of the instrument depends only on the paramagnetic properties of oxygen. No combustion, hot wire or consumption of the sample is involved. This precision analyzer uses the meticulously designed and manufactured Bristol Dynamaster recorder to indicate and record its measurements of oxygen content.



Dynamaster component takes to air

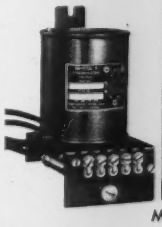
Official U. S. Air Force photo.

Flying high now, as a vital part in military aircraft like that shown above, Bristol's Syncroverter® switch got its start in the Dynamaster potentiometer.

Originally designed to help the Dynamaster endure extremes of shock and vibration (in steel rolling mills and the like), the Syncroverter switch or "chopper" is used now in aircraft to convert d-c signals to corresponding a-c signals, making possible use of highly stable a-c amplifiers.

The Syncroverter switch, noted in aircraft instruments and missile systems for its trouble-free life of thousands of hours, is one of the building blocks that make Bristol's Dynamaster the rugged instrument it is.

SYNCROVERTER switch for instruments.



MINIATURE SYNCROVERTER switch for aircraft.

Technical data available

We'll send you complete technical data on Dynamaster potentiometer and bridge instruments for measurement, recording or control. Or our engineers will be glad to discuss your specific application problems with you. Write today to The Bristol Company, 113 Bristol Road, Waterbury 20, Conn. 6.29

WHAT'S NEWS AT BRISTOL . . . WHAT'S NEWS AT BRISTOL . . .

For more information circle **27** on inquiry card.

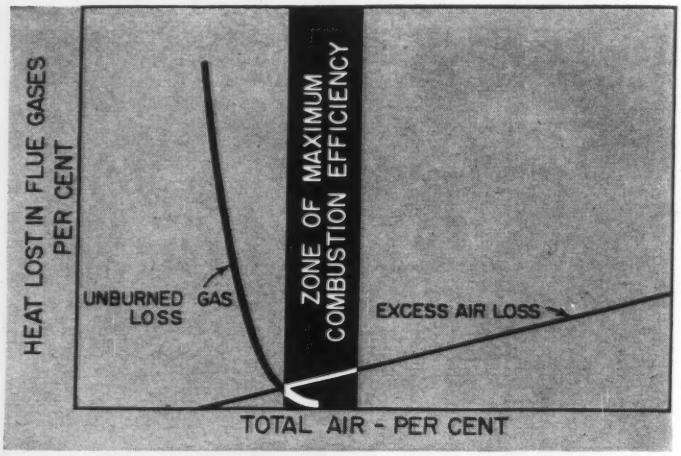
How to get maximum combustion efficiency . . . measure both combustibles and oxygen

Simultaneous measurement of both oxygen and combustibles is needed to obtain optimum combustion. No instrument that measures only one of these two interdependable factors can give you the full information necessary.

Now, Bailey offers two units, each giving a continuous and simultaneous double check on combustion efficiency: a permanent analyzer-recorder which records both factors on a single chart; and a new light weight, portable unit which indicates both factors.

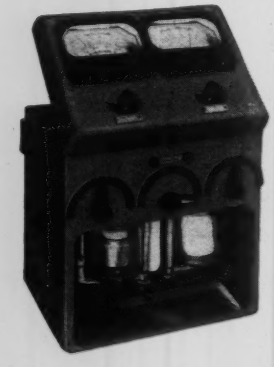
Both instruments measure: (1) excess air—regardless of the fuel or combinations of fuel being burned, (2) mixing efficiency of your fuel burning equipment by showing per cent combustibles in the flue gas.

Both units are designed to increase efficiency in the furnace operations of the steel industry, on glass tanks, cement and lime kilns, ceramic and refractory kilns, steam boilers and also on direct and indirect-fired furnaces in the metal processing industries. To prevent your money from becoming waste gas, look into these two efficiency provers. A Bailey engineer will be glad to give you details or write us for product specifications.


HEAT LOST IN FLUE GASES PER CENT
UNBURNED GAS LOSS
ZONE OF MAXIMUM COMBUSTION EFFICIENCY
EXCESS AIR LOSS
TOTAL AIR - PER CENT

Maximum Combustion Efficiency is secured by keeping the sum of Excess Air Loss and Unburned Gas Loss to a minimum. To do so by the direct method simply measure both oxygen and combustibles in flue gas.

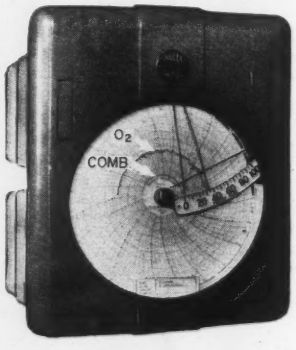
For portable use—
HEAT PROVER Analyzer



The famous Cities Service HEAT PROVER analyzer is now Bailey built and sold. Weighing only 25 pounds, it is a self-contained automatic analyzer including a sampling tip and hose plus a thermocouple for temperature measurement.

Instrument dials are dual range for greater accuracy and sensitivity.

For permanent installation
Oxygen-Combustibles Recorder



The Bailey Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart. These records enable the operator to keep fuel burning equipment performing continuously in the zone of maximum combustion efficiency. Excess air may be reduced to the point where combustibles begin to show.

G 40-1

Instruments and controls for power and process

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

For more information circle **28** on inquiry card.

MARCHANT CALCULATORS, INC., Oakland, Calif., announces election of *Dr. Arnold O. Beckman*, president of Beckman Instruments, to membership of the board of directors.

FISHER GOVERNOR CO., Marshalltown, Iowa has appointed *Fred Crabbe* and *Jerry Stebbins* sales representatives for New York and the surrounding territory. Their

F. Crabbe

J. Stebbins

organization will be known as Crabbe & Stebbins Company, with offices located in Englewood Cliffs, New Jersey, and Albany.

MINNEAPOLIS-HONEYWELL REGULATOR CO., LTD., Toronto, Canada announces election of *W. H. (Hank) Evans* as president.

MEASUREMENTS CORP., Boonton, N. J., announces election of *W. F. Mayer* and *G. Robert Mezger* as vice presidents.

THE HALOID CO., Rochester, N. Y., announces appointment of *William N. Hesketh* as advertising and sales promotion manager.

People IN THE NEWS

LEEDS & NORTHRUP CO., Philadelphia, Pa., presented a gold plaque to vice president *W. Richison Schofield*, celebrating his 40th anniversary of employment with L & N.

W. R. Schofield
L & N

J. R. Harkness
BJ

BJ ELECTRONICS, Santa Ana, Calif., announces appointment of *John R. Harkness* as vice president and *Paul J. Holmes* as technical director and technical consultant (electronics) to Borg-Warner Research Center, Des Plaines, Ill.

ARTHUR C. RUGE ASSOCIATES, INC., Cambridge, Mass., announces appointment of *Paul W. Koch* as executive vice president and general manager.

FREE

INFORMATIVE BULLETIN

How to set new highs in precision measurement of low temperatures

This special low-temperature Alnor Pyrometer is invaluable for balancing hot water heating systems, checking floor, wall or ceiling temperatures in panel heating systems, measuring temperature of refrigerated coils, insulation and all other low temperatures. Sturdy and completely portable, the Type 2300 can be taken anywhere—and give precise, direct readings in from 3 to 5 seconds.

Tear out this ad and attach it to your letterhead. Mail to Illinois Testing Laboratories, Inc., Room 518, 420 North LaSalle Street, Chicago 10, Illinois.

Alnor

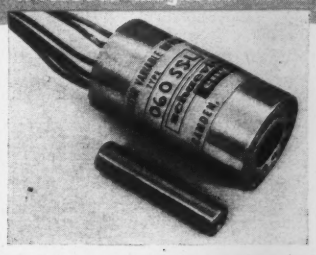
PRECISION INSTRUMENTS FOR EVERY INDUSTRY

For more information circle **29** on inquiry card.

INSTALL

Schaevitz Shielded LVDT's

wherever magnetic fields create a problem



SCHAEVITZ type 060 SS-L magnetically-shielded linear variable differential transformers can be installed with metallic mounts and clamps and in closely-spaced metal parts assemblies without fear of changing electrical characteristics of the transformers. They are insensitive to stray magnetic fields from external sources and are highly sensitive instruments for producing a voltage which is very accurately proportional to linear displacement.

FEATURES...

- LINEAR RANGE: ± 0.060 inch (total linear travel 0.120 inch)
- LINEARITY: within 0.5% of nominal full-range output
- LVDT RESOLUTION: unlimited —effective limit determined by user's indication or control equipment
- SENSITIVITY, 0.5 megohm load: at 60 cps: 1.4 MV out/0.001 inch/volt in— at 400 cps: 4.2 MV out/0.001 inch/volt in
- PRIMARY EXCITATION: 6.3V, nominal input
- FREQUENCY: for any chosen value in 50-20,000 cps range
- OUTPUT AT NULL POSITION: less than 0.5% nominal full-range output
- PHASE ANGLE, approx.: at 60 cps, 0.5 megohm load: 70°— —at 400 cps, 600 ohms load: 0°
- AMBIENT TEMPERATURE RANGE: —65° to +200°F
- PRICE: $27.50

WRITE, WIRE or CALL for more information on how this or other SCHAEVITZ shielded transformers can meet your needs.

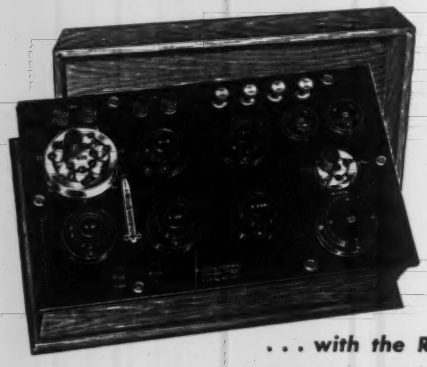
schaevitz engineering

P.O. Box 505 • Camden 1, New Jersey • Merchantville 8-5353

For more information circle **30** on inquiry card.

Precise

TEMPERATURE MEASUREMENTS



. . . with the Rubicon

MUELLER BRIDGE

A highly accurate and specialized form of the Wheatstone bridge designed expressly for precise resistance thermometry with three- or four-lead thermometers and for the measurement of other similar resistors within its range.

- Wide range: 0 to 141.1110 ohms in increments of 0.0001 ohm
- Unity ratio with provision for convenient checking and precise adjustment of ratio arms
- Built-in mercury commutator for lead resistance compensation
- Sub-panel switch construction
- Built-in plug and block assembly for conveniently checking ratio, bridge zero and thermometer resistance with no disturbance of external bridge connections

Described in Bulletin 100

. . . with the Rubicon

PORTABLE PRECISION POTENTIOMETER

A two-dial instrument of exceptional accuracy and sensitivity.

- High-sensitivity, sturdy, built-in Pointerlite galvanometer —permits balancing to within 2 microvolts in low resistance circuits
- Completely self-contained assembly—no external accessories except the thermocouple circuit
- Two ranges —0 to 16.1 and 0 to 161 millivolts—readable to within 2 and 20 microvolts respectively
- Sturdy, compact construction for long dependable service

Described in Bulletin 270

RUBICON COMPANY

Electrical Instrument Makers

3755 Ridge Avenue Philadelphia 32, Pa.

For more information circle **31** on inquiry card.

PEOPLE—CONTINUED

FENWAL INC., Ashland, Mass., announces appointment of *Allan S. Robertson* as vice president in charge of sales.

A. S. Robertson
Fenwal

J. Cardon
Servo Corp.

SERVO CORP. of AMERICA, New Hyde Park, N. Y., announces appointment of *Jules Cardon* to head the newly created industrial sales department.

GAMEWELL CO., Newton Upper Falls, Mass., announces appointment of *Robert B. Allen* as sales manager of the Signal Div., *Charles J. Manning* as sales manager of Precision Potentiometer Div., and *Herbert L. Gray* as advertising and sales promotion manager.

DAGE TELEVISION DIV., Thompson Products, Inc., Michigan City, Ind., announces appointment of *Wynne Stewart* to assistant sales manager in charge of equipment demonstrations.

BRUSH ELECTRONICS CO., Cleveland, Ohio, announces appointment of *Leo M. Monroe* as manager of

L. M. Monroe

J. Foster

industrial equipment sales and *Joseph Foster* as manager of market research department.

RHO ENGINEERING CO., Los Angeles, Calif., announces appointment of *Herman D. Rue* as chief engineer and *George L. McHale* as sales manager.

CONSOLIDATED ELECTRODYNAMICS CORP., Pasadena, Calif., announces appointment of *Eugene J. Moscaret* as manager of central regional office in Chicago. New district managers are: *Thomas E. Kurtzer*, Chicago; *Charles J. Leach*, Detroit; *William W. Cameron*, Philadelphia; *Donald E. Stocking*, Buffalo; *William W. Bumpus*, Washington, D. C.; *Vince M. Meagher*, Atlanta; *Don B. Schneider*, Los Angeles; *Eugene D. Pettler*, Seattle, and *Victor V. Myers*, Albuquerque.

TEXAS INSTRUMENTS INC., Dallas, Texas, announces appointments in the Semiconductor Div.: *Harry L. Owens* as chief engineer; *Boyd Cornelison*, *Charles E. Earhart*, *John R. Pies* and *Lawrence Congdon* as assistant chief engineers; *Cecil P. Dotson* as manager of manufacturing; *Robert W. Bronson* as production manager; and *Thomas E. Smith*, as quality control manager.

J. F. PRITCHARD & CO., Kansas City, Missouri, announces appointment of *Dayrel G. Hoke* as sales engineer of New York office.

NEW DEPARTURES OF TODAY

Microscopic inspection of races, one of more than one hundred operations undertaken to insure the highest degree of uniformity and dependability.

Super-cleanliness is a byword in this ball bearing assembly and inspection area. It is completely air-conditioned and pressurized to keep out dust.

Volume source for *miniature* ball bearings!

These tiny steel "jewels" are available in a complete line, 3/8" (.375") outside diameter and smaller. They are made with super-accuracy on the finest equipment available—much of it designed by New Departure—to meet the most exacting requirements of today's precision industries. Performance and dependability of the highest order are assured.

For complete information about miniature ball bearings, or for help with any bearing problem, call on New Departure's expert engineering service. New Departure, Division of General Motors Corporation, Bristol, Connecticut.

WRITE FOR NEW DEPARTURE'S MINIATURE BEARING CATALOG

GM GENERAL MOTORS

NEW DEPARTURE

BALL BEARINGS

NOTHING ROLLS LIKE A BALL

For more information circle **32** on inquiry card.

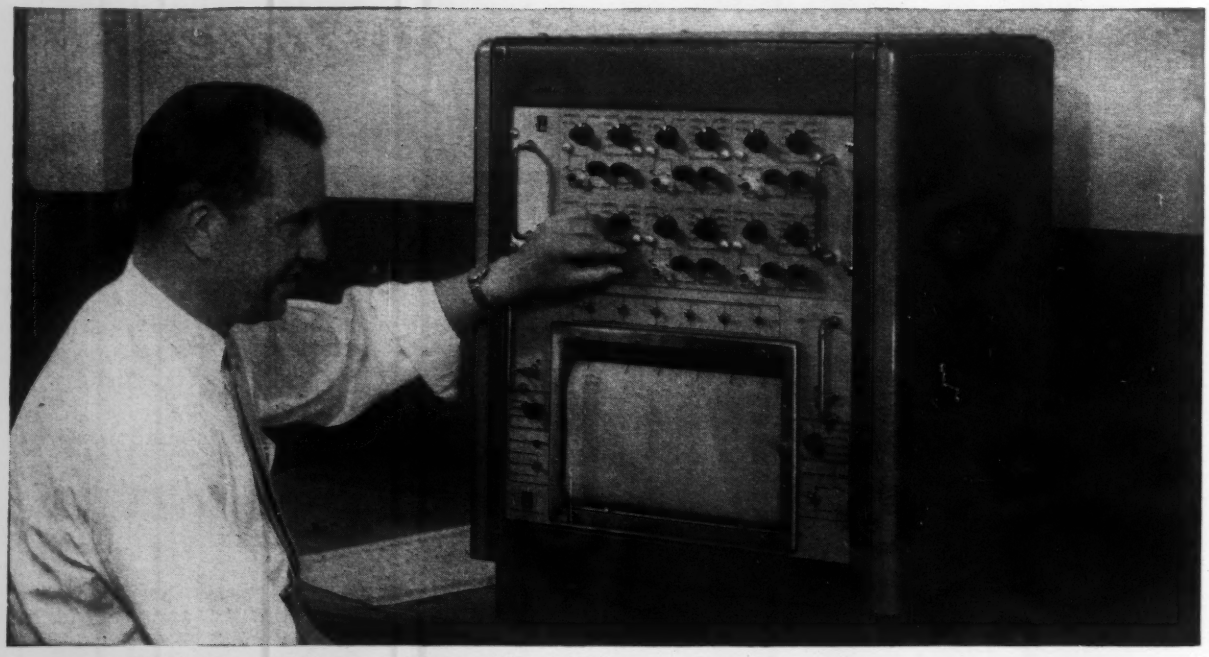
New instrumentation by Brush...

The new Brush amplifier permits more compact, flexible, multi-channel recording systems. Six completely interchangeable plug-in d.c. amplifier sections, plus power supply, plus a six-channel oscillograph, can now be mounted in a bench-top console only 29½ inches high.

The new design offers these outstanding features:

- *Measurement range from 0.050 to 400 volts*
- *Excellent zero line stability*
- *A unique internal calibration system*
- *Frequency response d.c.— 100 cycles*

Brush Recording Systems incorporating these new amplifiers are ideal for applications such as computer readout. Call your Brush representative or write for complete information.



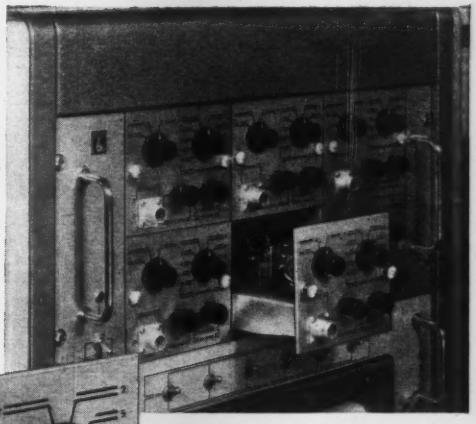
29½-inch console with new amplifiers contains complete six-channel recording system. New amplifiers take only *one-half* the space required by conventional units.

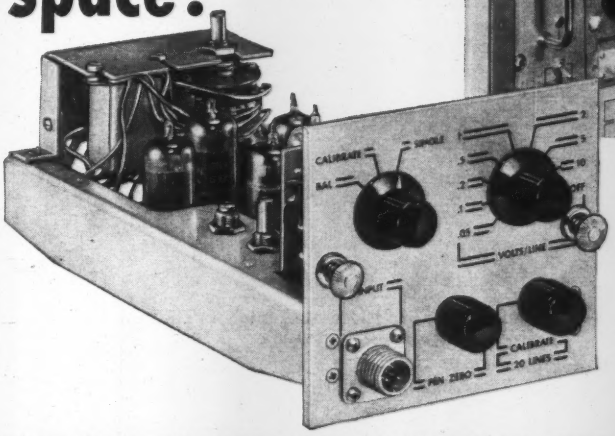
FOR COMPLETE INFORMATION

Write Dept. A-9:
Brush Electronics Company
3405 Perkins Avenue
Cleveland 14, Ohio

For more information circle **33** on inquiry card.

6-channel recording in far less space!

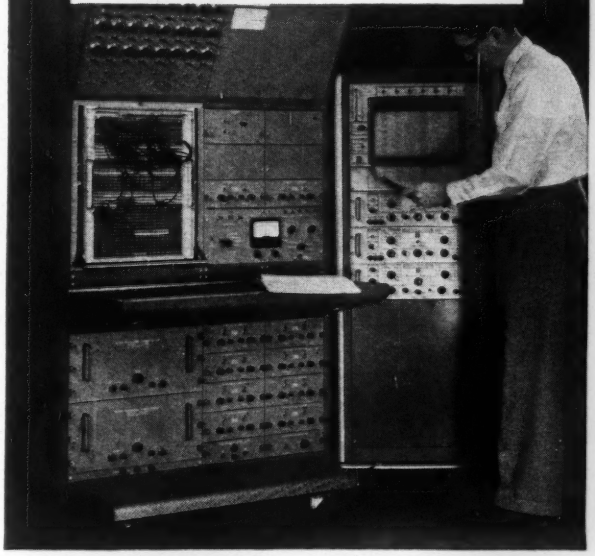




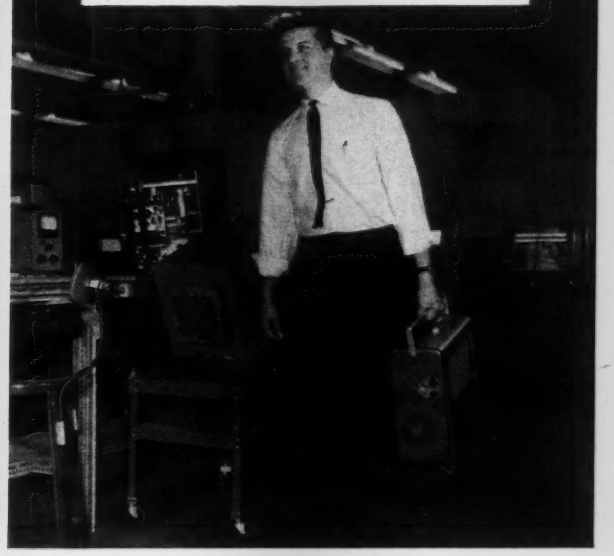
Plug-in amplifier sections are interchangeable, thus offer flexibility of operation. Systems can be "expanded" up to six-channel operation.

BRUSH SYSTEMS MEET ALL RECORDING REQUIREMENTS

Rack Mounting. Oscillographs and full range of amplifiers fit mobile instrument cart, or standard 19-inch racks. All Brush oscillographs offer a wide range of chart speeds, choice of ink or electric writing.



Portable Systems are ideal for measurements in the field, offer dependable accuracy under rugged conditions of use. All oscillographs and amplifiers available in portable cases.



BRUSH ELECTRONICS
3405 Perkins Avenue, Cleveland 14, Ohio

BRUSH ELECTRONICS COMPANY
DIVISION OF CLEVITE CORPORATION

For more information circle **33** on inquiry card.

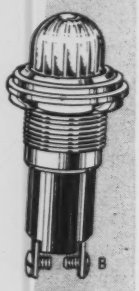
For
PILOT LIGHTS
CONSULT
DIALCO

Your product benefits 3 ways from the use of a DIALCO Pilot Light:

Enhanced appearance: The glow of light and sparkle of a lens add colorful visual attraction.

Greater safety: A timely warning flashed by a pilot light can prevent damage to equipment.

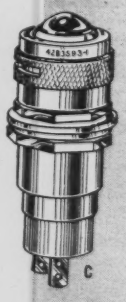
Added service: Discs inserted behind lenses can be used to deliver specific messages, such as "FUEL LOW", "ON", "OFF", etc.



Let the Dialco engineering department assist you in selecting the *right* lamp and the *most suitable* pilot light for your needs.

Dialco offers the *complete* line of pilot lights, from sub-miniature types to giant units with 1½" lenses.

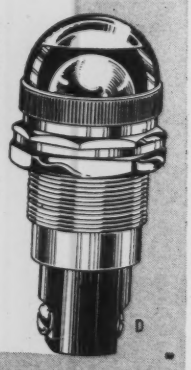
Every assembly is available complete with lamp.



SAMPLES ON REQUEST AT ONCE — NO CHARGE

Illustrations are approx. 70% actual size . . . *(A)* No. 8-1930-111 sub-miniature pilot light . . . *(B)* No. 521308-991, with multivue cap . . . *(C)* No. 922210-111, dimmer type . . . *(D)* No. 47901 with light shield cap.

Write for latest catalogues and Design Brochure.

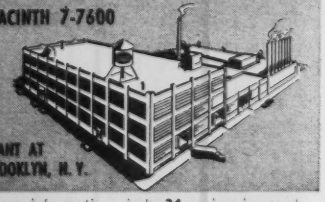


Foremost Manufacturer of Pilot Lights

DIALIGHT
CORPORATION

60 STEWART AVE. • BROOKLYN 37, N. Y.

HYACINTH 7-7600



For more information circle **34** on inquiry card.

Events

For other computer Events see page 1799

September 23-26

Petroleum-Mechanical Engineering Conference, sponsored by American Society of Mechanical Engineers, Conrad Hilton Hotel, Dallas, Texas.

September 24-25

Industrial Electronics Conference, sponsored by Institute of Radio Engineers and American Institute of Electrical Engineers, Hotel Manger, Cleveland, Ohio.

September 24-28

Joint committee for Automatic Control of German Association of Electronic Engineers, (VDE) and German Engineers Society (VDI) Conference on Automatic Controls, Heidelburg, Germany. For information write Verein Deutscher Electrotechniker (VDE) Osthofenplatz 6, Frankfurt 2/main, West Germany.

September 24-28

Trade Fair of Atomic Industry, sponsored by Atomic Industrial Forum, Inc., Navy Pier, Chicago, Illinois. Conference will be held at Morrison Hotel on September 25-27. For information write Atomic Industrial Forum, Inc., Exhibit Dept., 260 Madison Ave., New York 16, N. Y.

September 25-28

American Roentgen Ray Society Commercial Exhibit, Statler Hotel, Los Angeles.

September 30-October 2

Fall convention and Co-Exhibit of American Congress on Surveying and Mapping and American Society of Photogrammetry, Shirley-Savoy Hotel, Denver, Colo.

October 10-12

3rd Symposium on Vacuum Technology, Hotel Sheraton, Chicago, Illinois. For information write Axel H. Peterson, Chairman, Committee on Publications & Publicity, 4400 Fifth Ave., Pittsburgh 13, Pa.

October 16-18

Conference & Exhibits on Magnetism & Magnetic Materials, sponsored by AIEE, IRE, APS, AIMME, Hotel Statler, Boston, Mass. For more information write Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Penna.

November 26-30

Third International Automation Exposition, New York Trade Show Building, 500 8th Ave., New York, N. Y. For information write Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Penna.

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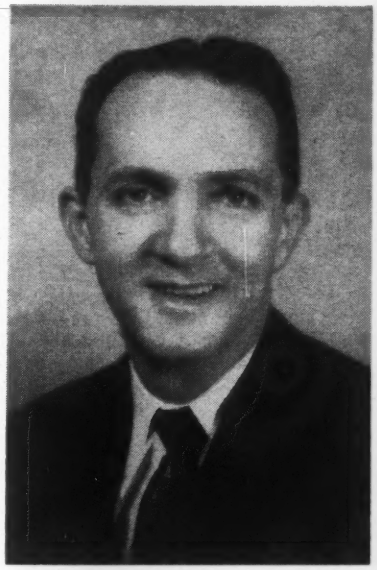
SIGNIFICANCE

Francis Becker, Chief Instrument Enginer, Marcus Hook Refinery of Sun Oil Company, is a leading personality in the process instrument field. His biography reveals several basic trends in process instrumentation—including its expansion in size, its trend to electronic techniques, and the growth of importance of the instrument specialists to the process refinery. Francis has been a driving force behind many of the important developments reported in his biography. We are pleased to acknowledge his contributions to our field —and his important position within it.

FRANCIS BECKER



Francis Becker was born in Philadelphia, Pennsylvania on February 24, 1908. He attended Drexel Institute of Technology (evening school) from 1927 to 1932 (Electrical Engineering Diploma Course). His first instrument experience began when he was employed by Leeds & Northrup Company in 1926, where he worked until 1932. He married Ella M. Dwyer in June, 1931.

In February 1932 he accepted a position with Sun Oil Company as Instrument Mechanic in their Marcus Hook Refinery. At this time there was no organized instrument department; five men working under different department heads serviced the instruments. Automatic control equipment consisted chiefly of temperature recorders and indicators, flowmeters, pressure gages and a few pressure recorders. Equipment was repaired in a corner of some other crafts shop, such as the Electric Shop or the Pipe Shop.

In 1939 Francis was advanced to Area Supervisor in the Instrument Department. By this time the Instrument Department had been formally organized and the refinery had been zoned into four areas, with an instrument shop in each area. The department now had 19 men servicing instrument equipment. Catalytic processes for the cracking of crude oil were beginning to revolutionize the oil industry. Their new processes required automatic control and gave instrumentation "a shot in the arm." This did much to increase the importance of a well-organized instrument department.

In 1946 Francis advanced to Assistant Chief Instrument Engineer. Increase in the number of operating units in the refinery, together with ever-increasing demands for more automatic control for the more complex refining techniques, again necessitated increased forces in the Instrument Department. The refinery was now zoned into six areas with an instrument shop in each area; now 55 men were required to service the equipment.

In 1948 Francis advanced again—to Chief Instrument Engineer. Further growth in the refinery made it necessary to increase the size of the department; 74 men now were required to service the equipment.

By 1955 continued growth of the refinery and the decision of the company to enter the petro-chemical field necessitated enlarging the department to 83 men. Due to the increasing complexity of some of the equipment, especially in the field of product analyzers, it became necessary to set up an Electronics Division in the Instrument Department under an Electronics Supervisor. The duties of this group are to design new electronic equipment for special analysis problems, check over new electronic equipment received from vendors, and to instruct the other instrument men in the servicing of electronic equipment.

At present Francis' Instrument Department is responsible for approximately 12,000 instruments.

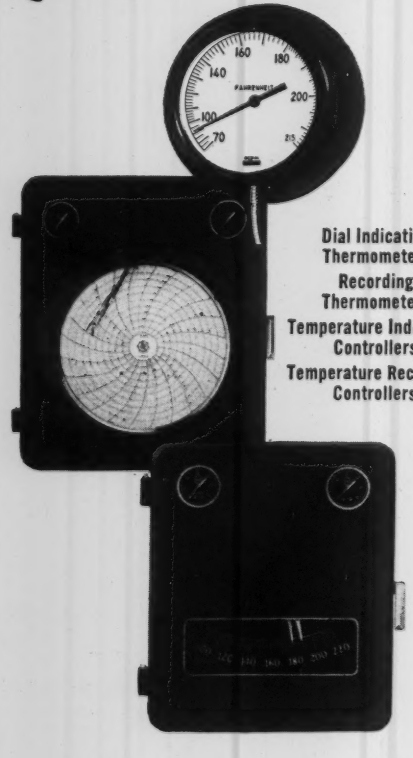
Francis is a charter member of the Philadelphia Section of the I.S.A. and served as president of that section in 1951. He is at present a member of the Recommended Practices Committee of the I.S.A. Sub-Committee on Support and Protection of Instrument Piping.

He has written several papers: "Instrument Shop Tools," presented at the Fourth National ISA Conference, 1949; "Instrument Maintenance Shops and Equipment," presented to the Akron Section, I.S.A. in 1952; "Sun's New Aromatic Plant," published in Minneapolis-Honeywell's *Instrumentation*, third quarter, 1954; "Level Measurements in Granular Solids," presented at Symposium of Materials Handling Instrumentation, 1954, and currently appeared in the February issue of *Chemical Engineering*.

Francis tells us "I have been reading *Instruments and Automation* since 1945. The magazine has always been interesting and instructive and has been a help in keeping my staff up to date on new developments in instrumentation. About twelve men in my organization subscribe to *Instruments and Automation*, and about 30 men in my organization read it monthly."

FILLED SYSTEM LEAKAGE

Now A THING OF THE PAST!



The statement is worth repeating. *"Filled system leakage is now a thing of the past!"*

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Instruments
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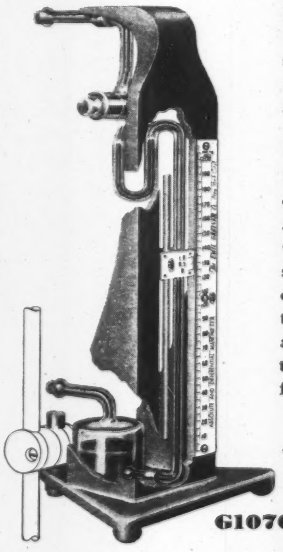
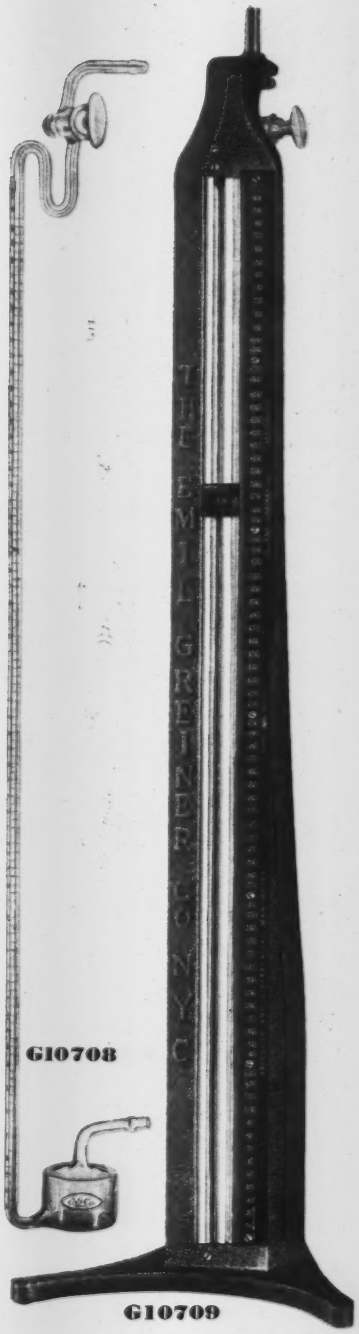


G10705



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G10709

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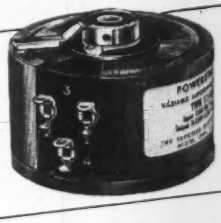
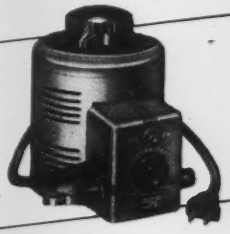


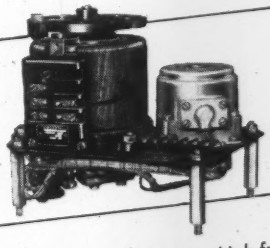
TYPE 10-1002 — With complete rotation; this compact unit is ideal for servo-mechanisms and temperature regulators.
INPUT: 120 volts, 50/60 cycles, single phase
OUTPUT: 0-120 volts, 1.25 amperes, 150 VA

PILOT LIGHT



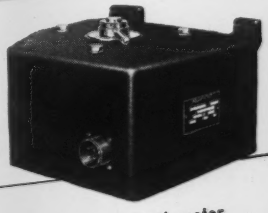
TYPE 116-1005 — A POWERSTAT of 1 KVA capacity with pilot light to indicate when unit is energized.
INPUT: 120 volts, 50/60 cycles, single phase
OUTPUT: 0-140 volts, 7.5 amperes, 1.0 KVA

MOTOR DRIVEN For 50 or 60 Cycles



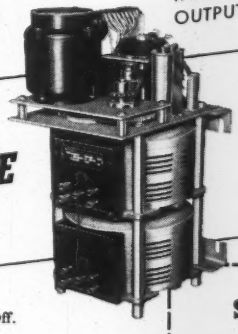
TYPE 116-1004 — A motor-driven assembly of 1 KVA capacity featuring rapid control and silent operation for use on 50 or 60 cycles.
INPUT: 120 volts, 50/60 cycles, single phase
OUTPUT: 0-140 volts, 7.5 amperes, 1.0 KVA

DUST PROOF CONTAINER



TYPE 1126-1001 — For high frequency applications — supplied in dust proof container with AN connector and screwdriver slot control with locking device.
INPUT: 115 volts, 400/800 cycles, single phase
OUTPUT: 0-130 volts, 15.0 amperes, 1.95 KVA

FOR TEMPERATURE CONTROL



TYPE 136-1003 — A motor-driven unit with potentiometer on shaft for temperature control applications using electric proportional control.
INPUT: 240 volts, 60 cycles, single phase
OUTPUT: 0-240/280 volts, 20 amperes, 5.6 KVA

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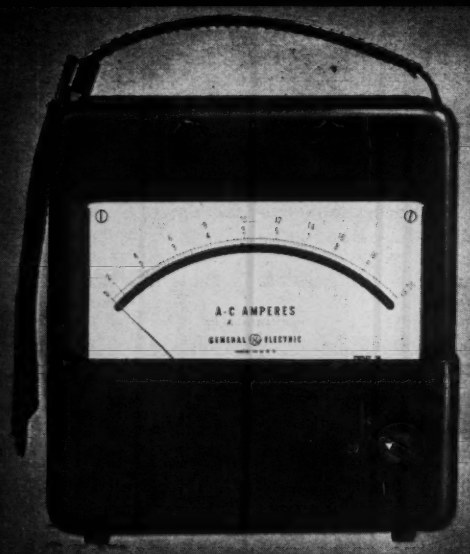
Instruments for Precision Measurements



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**Reg. trade-mark of General Electric Co.*

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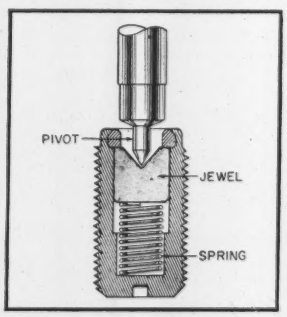
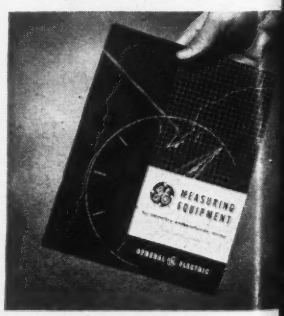
MORE UNIFORM SCALE DISTRIBUTION is now possible for high-accuracy a-c measurements. Note how much more precisely readings can be made, especially at lower end of scale. New window admits light from three sides.



SPRING-MOUNTED JEWELS cushion pivots to avoid pivot blunting and jewel cracking.



WRITE FOR BULLETINS—Ask for GEC-979, GEC-1384 and instrument catalog GEC-1016.

FOR FULL INFORMATION, WRITE SECTION 582-18, GENERAL ELECTRIC CO., SCHENECTADY 5, N. Y., OR CONTACT YOUR NEAREST G-E APPARATUS SALES OFFICE.

GENERAL ELECTRIC

For more information circle **40** on inquiry card.

electronic "brains" for industrial control

Do you need to measure and control weight, pressure, tension, torque or thrust? You can do it best with a Baldwin electronic SR-4® system—the system that's instantaneously responsive, highly accurate, always reliable and maintenance-free.

Easy-to-install Baldwin strain gage type transducers are the load-sensing elements. They transmit signals to Baldwin indicators, recorders, controllers, or other appropriate instrumentation . . . i.e., load cell output can also be fed to digital printer or computer.

Closed-loop SR-4 systems are engineered to meet your specific requirements. Find out now how these electronic "brains" can solve *your* control problems. For bulletin 4300, write Dept. 3053, Electronics & Instrumentation Division, BLH Corporation, Waltham, Massachusetts.

SEE OUR EXHIBIT AT THE INSTRUMENTS SHOW

ELECTRONICS & INSTRUMENTATION DIVISION
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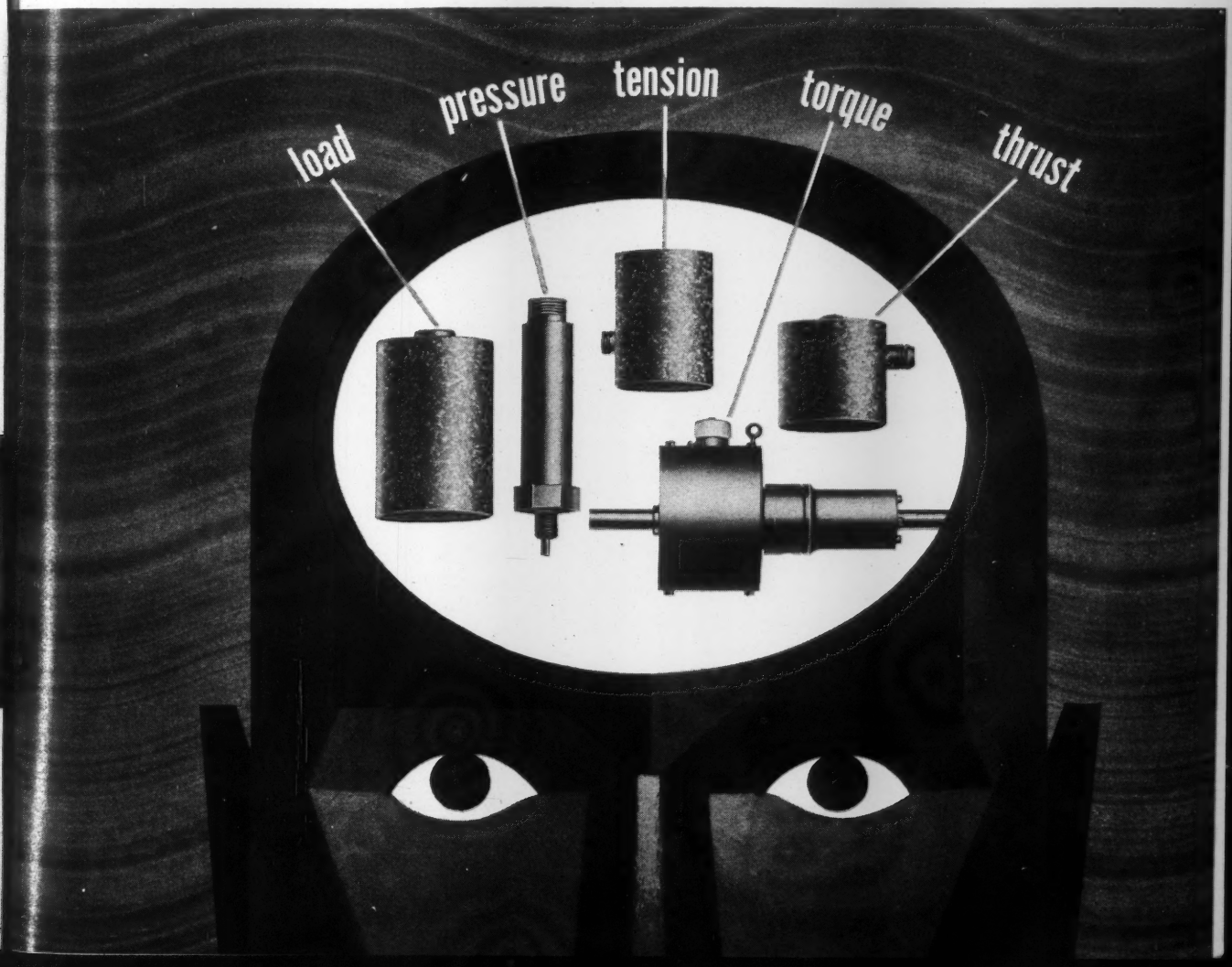
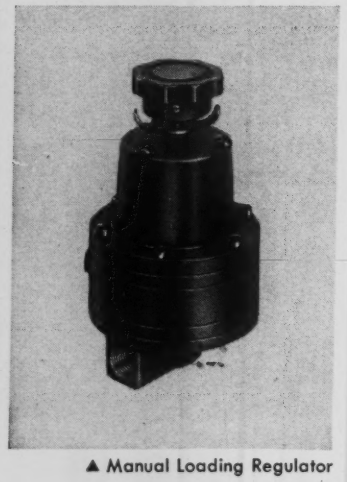


Standard Air Filter ▶



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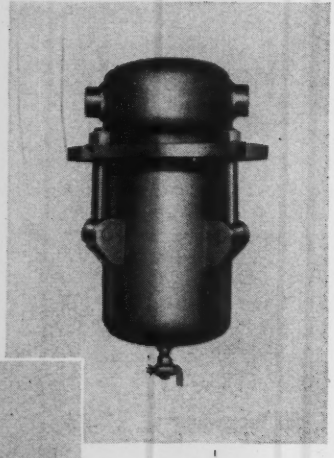
HONEYWELL SUPPLIES MAN

Performance-engineered filters and regulators for pneumatic instrumentation

Heavy Duty Air Filter ▼



Your pneumatic control instruments need clean, dry air at the right pressure to assure best performance. That's where Brown air filters, dripwells and regulators fit into your plant's control systems. Available through your local Honeywell Supplies Man, these essential accessories protect instruments . . . reduce maintenance . . . keep control performance at peak level. A complete line, in a range of sizes and capacities, gives ample choice to match your specific needs.

Ask your Honeywell Supplies Man about these air control accessories. And ask him, too, to tell you how the HSM Plan can apply personalized attention to all your instrument supplies purchases . . . with attractive dollar savings, reduction in inventory, and simplified paper work. Call him today at your local Honeywell office . . . as near as your phone.

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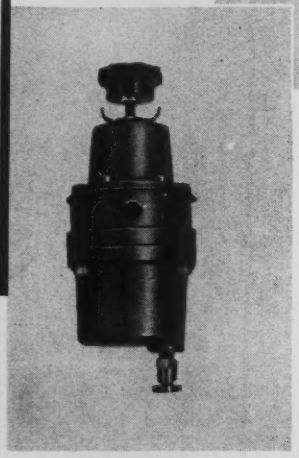

▲ Combination Air Filter and Pressure Regulator

● **REFERENCE DATA: Write for Catalog 8951, "Pneumatic Control Accessories" . . . and for the booklet, "The HSM Plan."**

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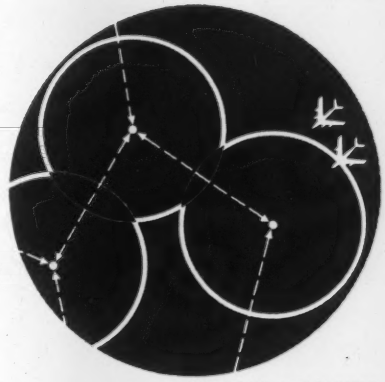

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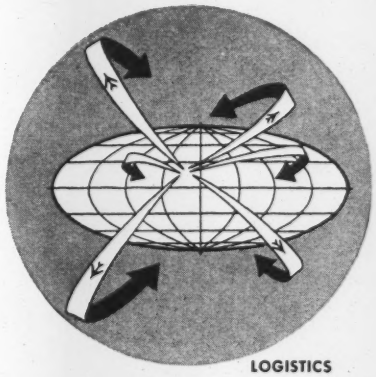
at Hughes

NEW HORIZONS IN **DATA PROCESSING**

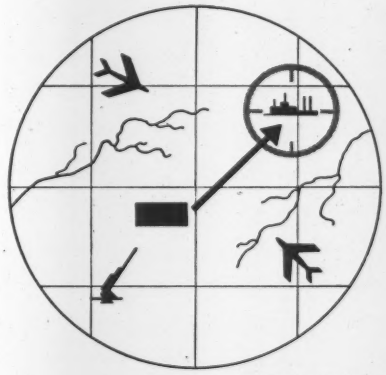
Hughes digital data processing systems are being used in the solution of one of our nation's most vital problems—defense against air attacks. In this age of atomic weapons and high-speed, high-altitude bombers, defense systems had to be developed which would supply anti-aircraft weapons with data on the position, speed, and direction of enemy planes. Hughes data processing systems surpass the most stringent requirements of modern anti-aircraft defense. Data may be received from many sources simultaneously; complex computing functions are carried out automatically; and data distribution is nearly instantaneous.

In the Hughes anti-aircraft defense systems, target information is received from radar stations. The system then accomplishes detection, identification, and tracking of enemy targets; storage and evaluation of the target data; and distribution of target and weapons assignment data to the anti-aircraft batteries. The batteries are thereby effectively coordinated in repelling the enemy attack. By linking together a number of such systems for the exchange of tactical information, a tight defense perimeter can be formed against aerial attack from any direction.

The contributions of the Ground Systems Laboratory have helped to make Hughes the West's leading center for advanced electronics. Hughes offers its Engineers and Scientists excellent salaries, constant challenge, and the luxury of Southern California living. For further information concerning the great opportunities at Hughes write us at the address below.



LOGISTICS



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Scientific Staff Relations

Research and Development Laboratories

HUGHES AIRCRAFT COMPANY
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HUGHES

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with experience in one or more of the following fields: pulse circuits, computer techniques, magnetic core devices, timing and synchronizing circuits, scalers, storage devices, analog to digital and digital to analog converters, and counting tubes.

ENGINEERS AND PHYSICISTS

for logical design of digital computer systems.

ELECTRICAL OR MECHANICAL ENGINEERS

experienced in the equipment design of digital computers. These engineers should be capable of working with schematic diagrams to design complete equipment packages. Knowledge of etched circuit design techniques is desirable.

COMPONENT ENGINEER

to select, evaluate or develop specialized components such as transformers, delay lines, capacitors, etc.

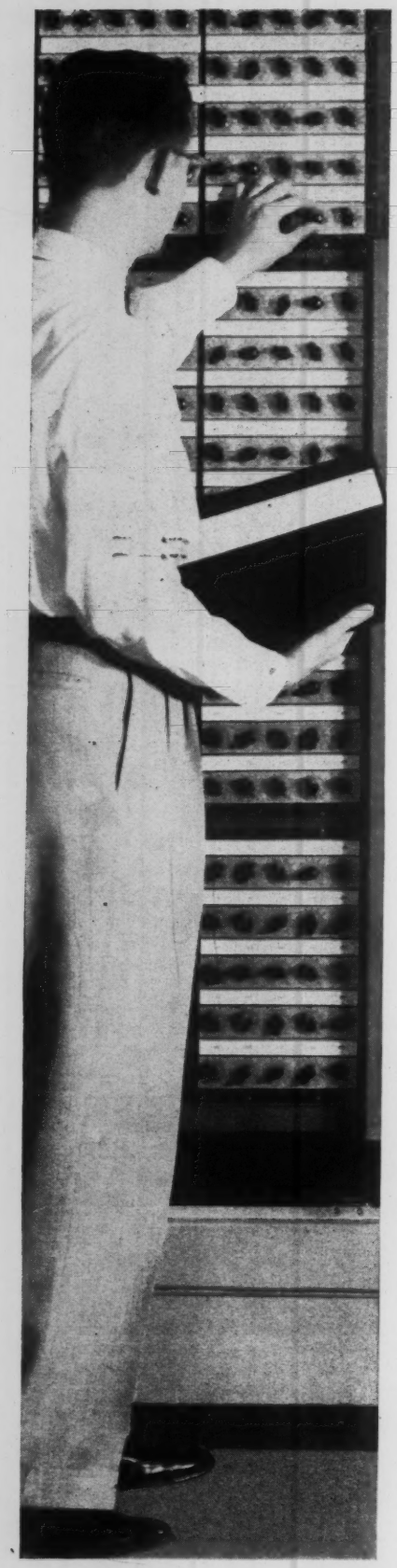
DATA SYSTEMS ENGINEER

to work on digital data processing in the area of storage memories and computer-type processing circuits.

MICROWAVE ENGINEER

for work on large high-gain antennas and transmission lines.

For more information circle **43** on inquiry card.



Panalog Information Systems guide management in raising plant output and profit

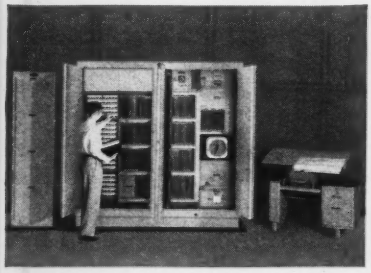
Panalog 605 Information System supplies management control information. Now, operating personnel and management can receive organized digital information on any process, instantly and continuously. Information can be presented in a variety of forms for immediate control action as well as for engineering and accounting analysis. A typical presentation method employs an electric typewriter and patented log chart. Readout can also be made on punched or magnetic tape, punched cards, or can be fed directly to computers.

Periodically logs and continuously scans. A precision servo measuring system quantizes process variables during automatic, periodic logging. A high-speed electronic measuring system detects off-normal conditions during continuous scanning of all variables. Normal and return-to-normal values are printed in black—off-normals in red. A complete log of all variables as well as a summary of off-normals can be made at any time.

Completely flexible and expandable. Panalog components are standardized, packaged modules. The system can be easily expanded or modified in the field. The Panalog 605 is sufficiently flexible to supply digital information for any management requirement.

Write for literature. Literature presenting a comprehensive treatment of the Panalog 605 is available. If you wish, a Panellit representative in your area will be happy to discuss the possibilities that a Panalog Information System offers your company.

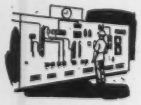
Full scale, adjustable, high and low off-normal limits are provided for each input variable. Basic system capacity, 200 points with one electric typewriter — can be expanded. Accuracy, ±.25% of full scale range. Logging speed, approximately one line per minute. Scanning speed, five points per second, between logs.



Logged values are grouped by processing unit on chart. Audio-visual alarms accompany detection of off-normals. When scanning, off-normal values are identified and printed in separate chart area. Totalized and averaged values as well as plant efficiencies can be automatically computed and recorded by the system.

U.S. Pat. No. 2,701,748

Engineered Information Systems For Industry



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Panellit Service Corp.

PANELLIT

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shows it in a nutshell . . .

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COMPRESSION SPRINGS Special Shapes Variable pitch

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EXTENSION SPRINGS Swivel End Drawbar

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WHAT CAN YOU DO about AUTOMATION?

YOU have read and heard a lot about **AUTOMATION.**
YOU have been told that it is going to revolutionize your own offices and plants.
YOU now have—for the first time—an opportunity to get lecture-demonstration classes on **operating automation equipments.**

YOU and your engineers and executives can now receive—for the first time—a practical down-to-earth education on how automation equipments operate, why they are used, when they are used, and how they are used. No theory; no generalities; no high-power promotion—just practical application instruction.

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Each registration (one course) applies to 6 classes; two each morning for 3 mornings and costs only $10. Ten of your engineers can thus monitor 60 different classes. You owe it to yourself and your organization to make full use of this valuable education in automation. Pick out six of the classes described here for yourself and six others for each of your production, research and management men. Each registrant will also receive a copy of the AUTOMATION HANDBOOK.

Classes will be held in conjunction with the Third International Automation Exposition, New York, N. Y., Nov. 26-30, 1956. In the mornings you attend classes; in the afternoons you monitor this giant exhibit which occupies all five floors of the New York Trade Show Building.

This is what you can do about automation.

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Ormig selective data printers which break down data from lists and prints them on single-item tickets. Selects and prints lines, columns, headings.

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Automatic cleaning operations are not only more efficient but more rapid.

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BRISTOL COMPANY
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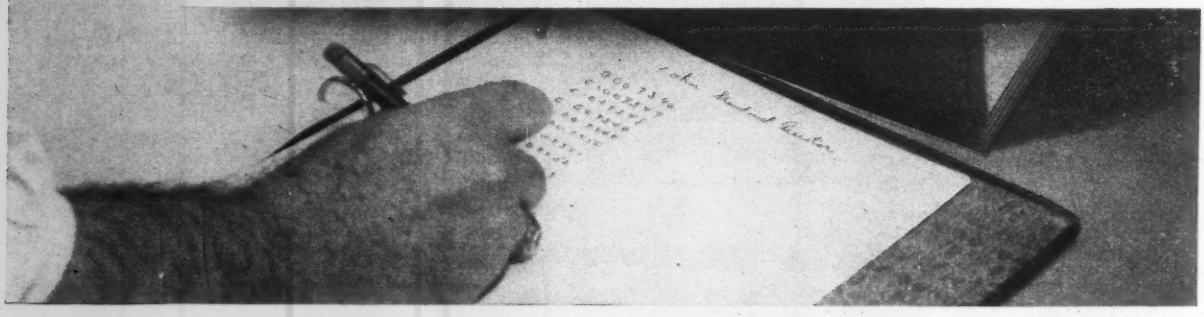
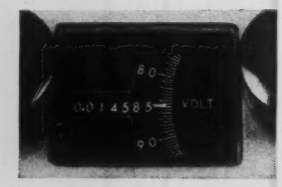
For more information circle 96 on inquiry card.

NEW! TYPE K-3 UNIVERSAL POTENTIOMETER

makes Precise Voltage Measurements easier than ever before



- **Scale reads directly in voltage**
- **Guarded against humidity, static, leakage of any kind**
- **"Thermal Free" circuit reduces voltage errors**



You take your readings directly from a central reading window . . . no more mental arithmetic in adding up dial settings. You can use this unique instrument in hot, humid weather . . . in cold, dry weather . . . without worrying about leakage or static.

The many new design and construction features . . . metal case for electrostatic shielding . . . guarding of battery and detector circuits . . . enclosed switches and slidewires . . . thermal free circuit construction . . . central reading window . . . make this Type K-3 Universal (Guarded) Potentiometer the most advanced general purpose instrument available today. You will find it a worthy new addition to the Type K line . . . originated some 50 years ago . . . the world's most widely used precision potentiometers.

Six pages of data are required to give you full details. Ask for Data Sheet E-51(6); write your nearest L&N Office or 4955 Stenton Avenue, Philadelphia 44, Pa.

LEEDS [N] **NORTHRUP**
instruments — *automatic controls • furnaces*

For more information circle **46** on inquiry card.

INSTRUMENTS and AUTOMATION

AUTOMATION: The use of devices—mechanical, pneumatic, hydraulic, electrical and electronic—for making automatic decisions and efforts.—***M. H. Aronson***, Editor

Editorial

An Engineer Looks Inward

This "letter to the editor" touches upon sensitivities deep in the soul of many engineers in this age of automation and nuclear power. The author has consented to its use as a guest editorial.

Editor, I&A:

Although I am about a year behind the wake of the famous editorial, "Automation and Culture," and a month behind the equally impressive one, "The Social Reactor," I would like to make a few pertinent comments which concern the philosophy of each of them. Perhaps these could be considered anniversary best wishes to the editor for his famous statements of a year ago!

I am a conservationist by nature and a mechanical engineer by profession. Because of my nature and because of my profession I am continually fighting a tug-of-war within myself, and I believe that this conflict is reflected to some degree within the private lives of many technical and professional men like myself, particularly within those who, in order to keep up with the rapidly changing events and discoveries within their vocation, must continually alter their point of view and frame of reference, if not daily, certainly monthly and yearly.

On one hand, I am eager to learn about, and to help make, new discoveries and contributions to our technical civilization. On the other hand I worry a little about the effects of these discoveries upon mankind. Sometimes I become so very immersed in an engineering problem that I lose sight of its solution in terms of the overall project of which it is a part. I become literally overwhelmed with data, with graphs, with notes, with literature references, and with scrambled ideas. I believe other men often find themselves in this situation. My only defense against being overwhelmed and frustrated is to separate myself periodically from the data and decisions that form my daily work.

I take mental trips, and sometimes physical trips, away from my desk. I engage in a modicum of exercise and hobbies during my spare time, like most persons in every walk of life. But these alone do not give me the perspective I seem to require in order to evaluate my location within my profession. I must learn about progress in other fields, too, such as art, music, philosophy, economics, history, politics, literature, science and sociology; and in the process of reading about these fields I find that sometimes I wish to practice in some of them just a little, if nothing more, for example, than to write a bit of poetry, or to play haltingly on the piano, or to sketch with pencil or water color, or to observe the magnificent sights on the moon or farther out in the universe, through my small telescope.

I find, too, that occasional jaunts into the wilderness of the mountains, where living simply on the barest necessities, and with plenty of physical exercise, give me the spiritual food that my soul seems to require. All these activities—reading, practicing a little in other fields, conversation, nature rambling—do seem to help me continually to re-orient myself in my chosen work. After "returning to Earth from the Moon or from the Great Nebula in Orion" or from a winter camping trip in the White Hills of New Hampshire, my urge to escape has spent itself and I am eager again to tackle my engineering problems. Somehow my mind seems clearer, my body more relaxed, my temper more even, and my spirit on a higher plane than before.

I know that I speak for a large number of other engineers and persons like myself. Many of us like to reflect back into ancient history for the old and classical cultural values. These comparisons frequently reveal to us beacons and landmarks from which we gain inspiration, not only for our specific problems in our daily work, but also for the long range studies and developments, to which there frequently must be attached an economic, and sometimes a philosophic, value. When a man works on a measurement or control problem he finds great satisfaction in achieving his immediate objectives—but he now and then thinks about the effect of his work on society as a whole.

To some people the phrase "Automation and Culture" can be equated with the phrase "evil and good," in the same order. These people believe that automation will displace too many persons from industry too fast, and therefore it is considered a great and foreboding evil, particularly on the horizon of labor organizations. No doubt these dissenters have done some good in at least calling the attention of the economic and technical developers of automation to some real and urgent problems. I class myself a dissenter too, but not in the same sense. I only suggest that those who apply either capital, knowhow or manpower to develop automation take interest also in the economic-social problems of our times so that malevolent developments in the latter do not destroy the fruits of the former.

Just as the nature conservationist must continually struggle to keep unwise materialists from encroaching

EDITORIAL—CONTINUED

upon wilderness areas and national parks in order that these may exist for those persons who are sustained, in an increasingly complex civilization, by the physical and spiritual values of Nature, so must the technical men of broad interests and profound vision help to keep among their goals the philosophy of the Brotherhood of Man, all the while they are probing deeper into the extremes of the atom and of the cosmos. Scientists like Albert Einstein, Robert Oppenheimer, Robert A. Millikan, and many others who have inquired deeply into the nature of our universe, have been articulate in maintaining that the search for supreme spiritual values should be the Noblest Aim of Man, and that his material aims should always be placed at a secondary level. This is, of course, not to say that one should give up one's search for Truth in any materialistic field, but only that the search, however conducted, should maintain a balance between humanistic and scientific values.

It is a good and important thing to raise questions about the cultural aspects of any new scientific development. Such questions should be asked frequently, and in many places, so that the true nature of the advancement can be wisely evaluated in the society of which it is to be a part. It is heartening to note that *Instruments and Automation* can look down upon itself, as it were, to observe now and then just where it fits into the overall scheme of things. Though its mission is primarily a technical one, it seems to realize that its responsibilities cover a much wider range of knowledge than mere technics.

We need more editorials like "Automation and Culture" and "The Social Reactor" to wake us up, to make us pause a little from our test data, to see beyond our slide rules. Once a year is not too often to be reminded that scientists and humanists need to learn to speak each others' languages, that they must do so in order to search together, in mutual respect, and in friendship, for the Answers toward which they strive. Great Questions need to be asked of every generation and many times within that generation. The fight for freedom, peace, and a happy life is continual. Its aspects change but its urge is the same in all peoples.

Whatever, and wherever we fight, let us do so with a clear and noble Goal ahead, so that, like the good camper and outdoorsman who leaves his campsite better than he found it, the good citizen will leave his society better for the lives of those who will come after him.

Clifford B. Haughton, Jr.
Montgomery, Penna.

Dear D.R.*:

Hope you had a nice time on your vacation this summer, and are now ready for a big fall and winter season—and it does look like a big one is coming up. The ISA Show is over (we'll have a show report next month for those of you who weren't there) and the Automation Show (Nov. 26-30, New York) is ahead. The latter has some revolutionary new ideas associated with it and the entire technical fraternity will be watching to see how it works. Nearly 300 90-minute classes will be devoted to lecture-demonstrations on operating automation equipments. Between 1000 and 2000 men are expected to enroll for these courses—in addition to the tens of thousands expected at the Automation Exposition itself. Never before has a show been converted into a mass-education school on the scale planned for the Third Automation Exposition. This is truly a courageous and visionary plan. One of the new instrumentation papers recently pointed out in an editorial that trade shows need more basic education classes. Well, here they are.

There are several exciting articles in this issue for you this month. In the past few months you learned about most of the basic principles of digital automation—binaries, multiplexing, converting, etc. One of the most important fields of application is in automatic data reduction, and Martin (Klein), Frank (William) and Harry (Morgan) continue their series this month on this subject—and in their inimitable manner. They show how on-line automatic data reduction works, what considerations must be resolved, and the advantages of film recording of the digital data.

You know the great emphasis we have placed on computers in the past few years. The series of articles you received last year that now comprise *The First Computer Handbook* is being used as a basic text from California (NAMTS, Point Mugu) to New York (GE, Syracuse). The larger *Second Computer Handbook* soon will be available—and it will contain the article you will find on pages 1773-1779. This article—"The G-15 Digital Computer" by Herb Lewis—is a much-needed and thorough introduction to the general-purpose digital computer for scientific and engineering problems. You will really know how such computers work after you read this article, and the only thing better than this that we know about is to come to New York in November and hear Herb lecture and demonstrate the G-15 in person (at the Computer Clinic of the Third Automation Exposition). He gives a tremendous presentation—as you will no doubt detect from reading his article.

Many D.R.s have written to us asking for more transistor circuits in our Electronic Circuitry feature. You will like to see the good ones on pages 1780-81. They teach a lot about transistor circuitry.

We placed the article on "Flight-Table Instrumentation" near the *Simulation Council Newsletter* this month because both cover the interesting subject of coordinate transformation. Between them you will gain much practical insight into this interesting subject.

Ah—valves. Yes, there is exciting valve material this month also. We found Chet Beard's coverage of "Positioners for Diaphragm Actuators" thorough and educational—and the article "Recent Developments in Solenoid Valves" by Frank Reeves (pages 1800-07) is again some of the best material that we know about on this subject.

If we had room to spare, your editors would tell you about the interesting summer we spent, the plants we visited, the people we met—but we are sure you would rather read about things of value to you than of interest to us.

Hope this finds you well and happy this month.

Cordially,
Milt and the Editors

P. S. Panhandle Pete reports such high interest in his Kanarienvogel gas analyzer, including phone-call inquiries from various parts of the country (no kidding), that he is seriously considering going into the business. Vast empires have started this way.

*Dear Reader

From MOOG . . . a Dual Input Servo Valve for Flight Control

Pilot boost servos for control surface positioning are commonplace. These servos are usually necessitated by high control surface aerodynamic loads which make direct control through the pilot's stick impracticable. Generally, they are mechanical-hydraulic in nature.

Today, as aircraft operational requirements increase, it is necessary to add artificial flight stability augmentation through these servos. Also, aircraft autopilots must work through this medium. These modes of operation generally require electro-hydraulic servos.

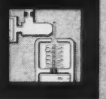
To coordinate these functions, the Moog Valve Company introduced, and is now in full production on, its Dual Input Servo Valve. These units permit direct mechanical-hydraulic flight control, combined mechanical-hydraulic and electro-hydraulic control, and electro-hydraulic control alone. Full mechanical override for safety is always possible and self-contained solenoid and lock-out arrangements permit full flight mode selection.

Employing an entirely new principle of summation, the Moog units accomplish the electro-mechanical mixing function without linkage in a single, integrally-designed package. By elimination of linkage inertia and backlash, the Moog Dual Input Valve greatly increases low amplitude resolution and frequency response. It simplifies the entire control system and is far more compact than other dual input mechanisms.

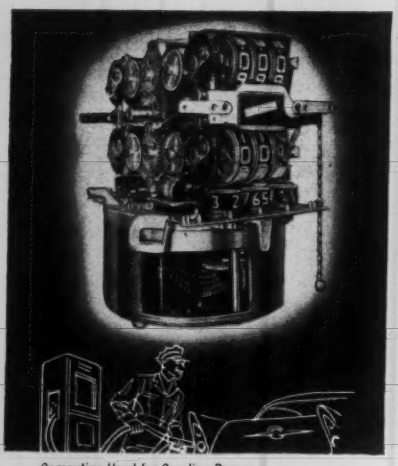
The Dual Input Servo Valve was developed by Moog's creative engineering staff. This team approach is available to industry to produce advanced electro-hydraulic servo components.

MOOG VALVE CO., INC., PRONER AIRPORT, EAST AURORA, N.Y.

MOOG



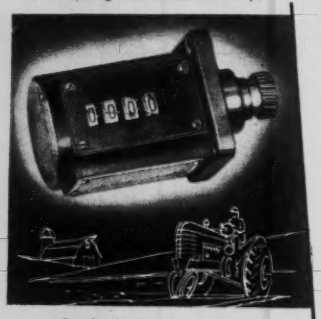
For more information circle **54** on inquiry card.



Computing Head for Gasoline Pumps

"Master Meter Duplicator" prints receipts for fuel oil delivered from trucks

"Vary-Tally" Multi-Unit Reset Manual Counter



Rev-Counter for all types of engines

Everyone Can Count on VEEDER-ROOT

Everywhere you look in everyday life, you see a familiar face . . . the face of a Veeder-Root Counter or Computer. From gasoline pumps to fuel oil trucks to textile mills . . . in the home, on the farm, in business and commerce, in modern automated industry . . . Veeder-Root standard and special devices are keeping everything under *Count*rol . . . manually, mechanically, electrically. And the mathematical probabilities are mighty high that *you* can count on Veeder-Root, too . . . to your advantage and profit. Why not let us figure out how, *right now?*

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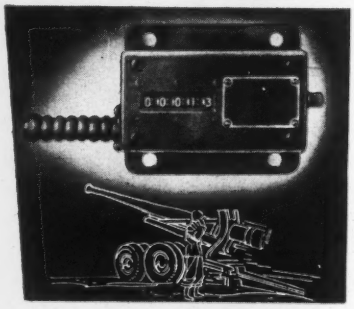
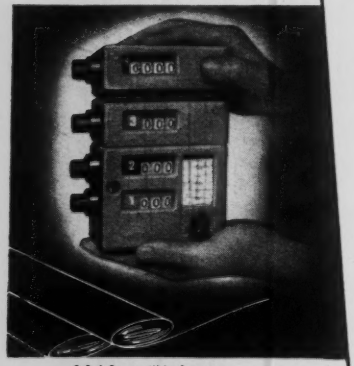
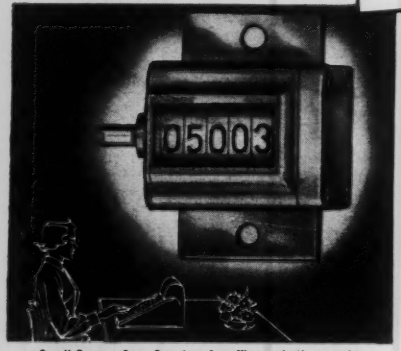


Recoil Counter for new 280 mm atomic cannon

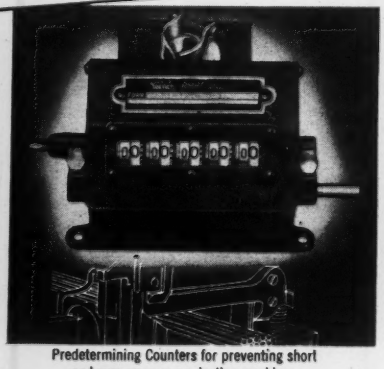


2-3-4 Convertible Counters (and others) for textile machinery

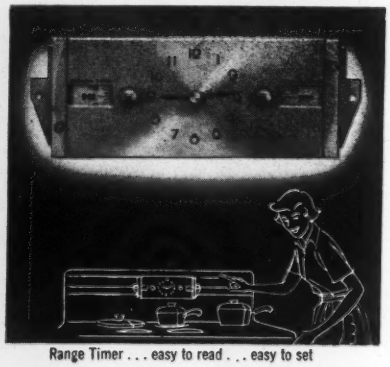
Fuel-Remaining Counter for aircraft . . . subtracts as fuel is used



Small Square-Case Counters for office and other machines



Predetermining Counters for preventing short and over-runs on production machines



Range Timer . . . easy to read . . . easy to set

STOCKS OF STANDARD COUNTERS AVAILABLE AT — Greenville, S. C. • Chicago 6, Ill. • New York 19, N. Y. • Los Angeles • San Francisco Montreal 2, Canada • Offices and Agents in Other Principal Cities

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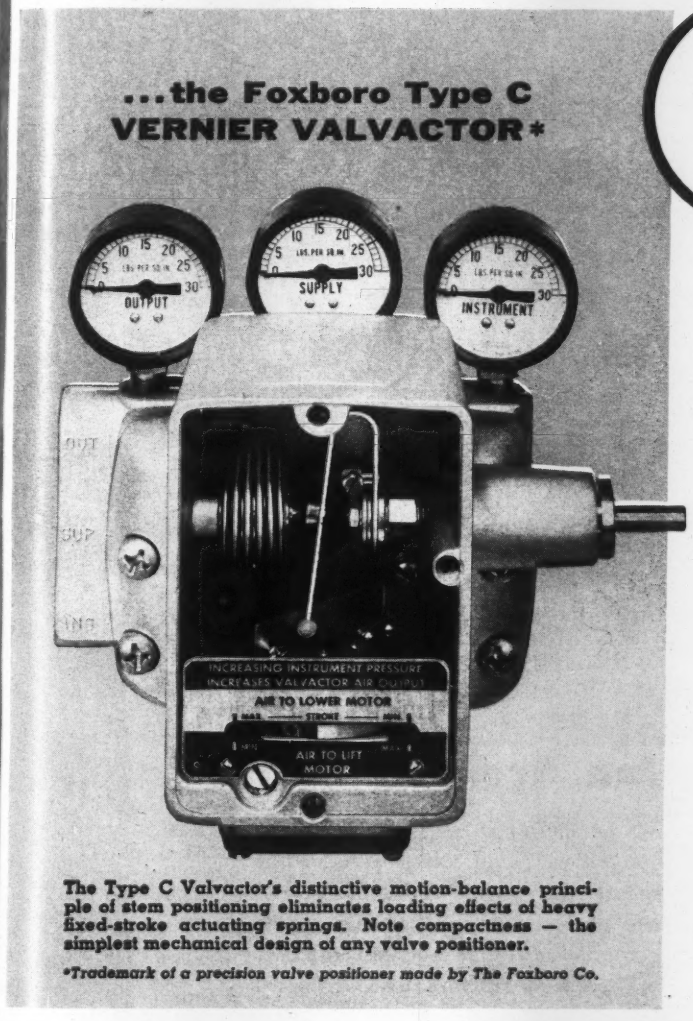
NEW!

MOST UNIVERSALLY ADAPTABLE VALVE POSITIONER ON THE MARKET!



The Type C Valvactor's distinctive motion-balance principle of stem positioning eliminates loading effects of heavy fixed-stroke actuating springs. Note compactness — the simplest mechanical design of any valve positioner.

**Trademark of a precision valve positioner made by The Foxboro Co.*

Unique Flexibility Easily reversible in seconds. Sequencing by two simple adjustments.

Super Response Full air-pressure output to diaphragm motor on signal air-pressure change as small as ½ of 1% of signal span.

Extra Speed New, high capacity relay provides high speed positioning action.

Positive Positioning Direct, motion-balance feed-back assures instantaneous, pin-point positioning.

Now there's a positive-action, super-precision valve positioner that you can easily adapt to *any* diaphragm motor application — without exchange of parts! It's the Foxboro Type C Vernier Valvactor with unique motion-feedback.

The Type C Valvactor has a master setting disc which provides easy change of action as required by the control system, as well as easy reversal of Valvactor action for air-to-open or air-to-close control valves. Adjusting for limited stem travel is equally simple . . . sequencing of several valves is a cinch!

The Valvactor is the ideal solution to such problems as stem friction, plug friction, valve motor and transmission line lag, and extreme process line pressure changes. And it requires practically no maintenance! Available with 3-gauge and by-pass manifold, or plain manifold. Write for full details.

The Foxboro Company, 469 Neponset Ave., Foxboro, Mass., U.S.A.

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VALVE POSITIONERS

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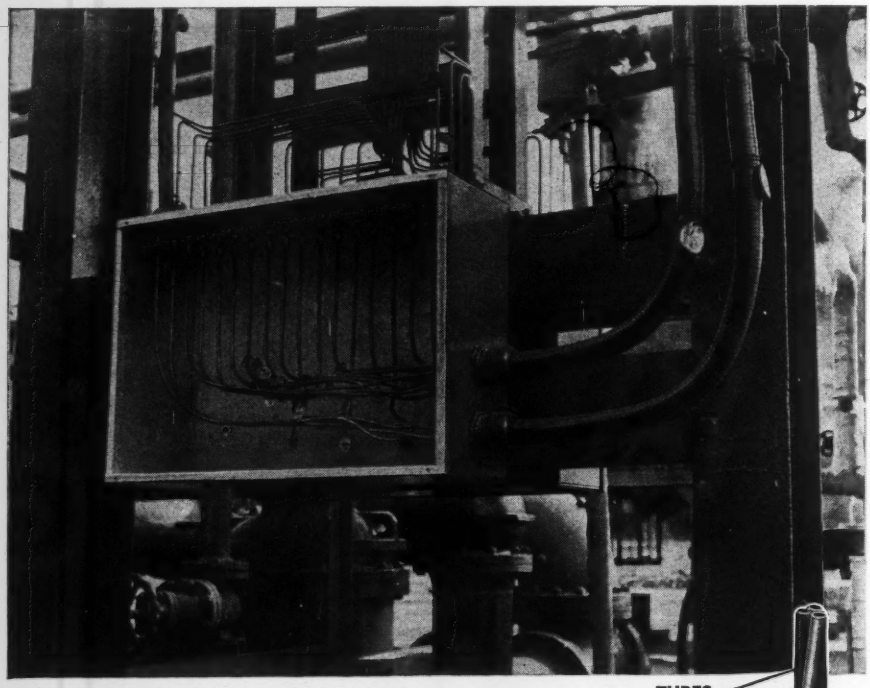
CRESCENT ARMORED MULTITUBE

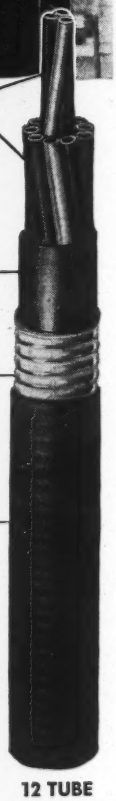
On The Industrial Unit At The Bayway Refinery of ESSO STANDARD OIL COMPANY

....proved easy and economical to install....

The illustration shows CRESCENT ARMORED MULTITUBE as it enters the junction box from the right, connecting with individual tubes for relaying to the elaborate instrumentation system.



12 Tube CRESCENT ARMORED MULTITUBE with thermoplastic sheath over flexible steel armor, feeding into CRESCENT Plastic Coated, Single Tube.



12 TUBE TYPE CAT

....and it is the Solution to Your Corrosion Problems

CRESCENT ARMORED MULTITUBE is a complete system of tubing for effective pneumatic and hydraulic instrument controls. It consists of long length tubes TWISTED TOGETHER to permit bending without distortion. In each layer one tube is a bright blue color, affording a fast means of identification of each tube at both ends. It is available with 2 to 37 copper tubes, ¼" O.D. in continuous lengths up to 1000 feet. Also furnished in aluminum, steel or polyethylene tubes, and in ⅜" and ½" O.D. sizes.

The type illustrated here provides maximum protection against corrosion, as well as mechanical injury to the tubing during and after installation. Substantial savings can be made on *installed* cost as compared with conventional single tubing. CRESCENT Armored Multitube gives a *better protected* and more *permanent installation.* Special construction is also available for permanent, direct-burial underground. This product is licensed under U. S. Patent 2,578,280.

Send for NEW Bulletin No. 356-A With Complete Engineering Data

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For more information circle **50** on inquiry card.

Books

Applied Electrical Measurements, by Isaac F. Kinnard. (c 1956) John Wiley & Sons, Inc., New York, N. Y. 600 p. + XI. $15. A reference book intended to cover basic principles of commonly employed electrical measurement devices and their application to measurement of electrical and nonelectrical quantities. Sufficient theory is given for an intelligent application of the principles involved to be made. Liberal references are included so that those who wish to may make a more thorough study. Includes brief history of electrical indicating instruments, and then covers galvanometers, bridges, and other instruments for measurement of current, voltage, resistance, power, etc.

Inverse Feedback, by Alexander Schure. (1956) John F. Rider Publisher, Inc., New York 13, N. Y. 56 p. Paper. 5½" x 8½" 90¢. 15th in series, explains principles and applications of inverse feedback as applied to cathode followers, Williamson amplifiers, VTVM's, etc.

Frequency Response, by Rufus Oldenburger, PH.D. (c 1956) The MacMillan Company, New York, N. Y. 372 p. $7.50. Papers and addresses presented at the 1953 A.S.M.E. Frequency Response Symposium plus ten additional articles. Linear, nonlinear, sampling, and statistical approaches are treated and experimental methods of frequency response are applied to process controls, servomechanism design and power systems. Book includes criticism of each paper, eight-page bibliography, and 428 illustrations.

Dynamics of Machinery, by James B. Hartman. (c 1956) McGraw-Hill Book Company, Inc., New York, N. Y. 283 p. The author extends a two-dimensional consideration of kinematics and dynamics to three-dimensional cases by means of vector notation, providing a transistion from basic work in mechanics to more advanced graduate work in dynamics. He shows the current practical applications of mathematics and dynamics and introduces certain mathematical techniques now becoming widely used in the literature of automatic controls and servomechanisms.

SELF ALIGNING SHAFT—
linear motion
potentiometers

BOURNS
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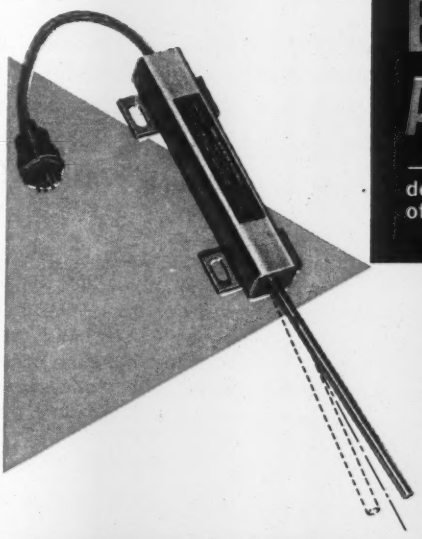
—highly reliable
despite misalignment
of actuating member



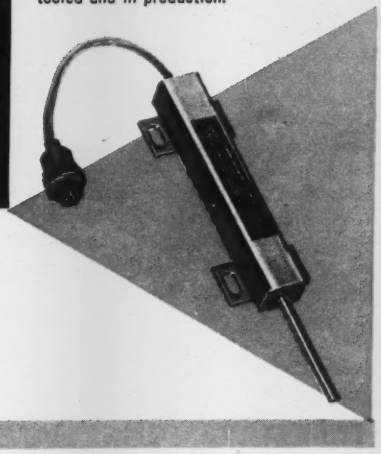
Here is a far-reaching advance in linear motion design. This unit allows for misalignment between the instrument and actuator—eliminating shaft side loads. With no alignment needed, the unit is mounted and installed quickly...is easily designed into a system.

To insure low noise characteristics under extreme vibration, the ALIGN-O-POT wiper assembly is supported throughout its entire travel by parallel guide rods. This provides continuous support directly at the point of contact...multiple contacts are used to further increase the reliability.

The ALIGN-O-POT has a stainless steel case and a flexible cable with plug connector. Standard travels are available from ½" to 6½". Other travels can be provided up to 36". The ALIGN-O-POT is fully tooled and in production.

BOURNS
LINIOMETER®

high performance
under environmental
extremes



The LINIOMETER has a bushing-supported shaft and the same highly reliable internal construction as the ALIGN-O-POT—for use where the self-aligning feature is not applicable. Small cross-section and optional mounting configurations are added features of these units. Available in standard travels from ½" to 6½".

the complete line of linear motion potentiometers

Bourns offers a wide selection of standard instruments for any need from ⅛" to 36" travels—all built for maximum reliability and optimum performance. Bourns will work with you on special requirements.

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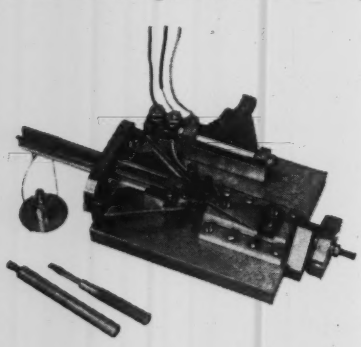
putting IDEAS *to work—research at* IBM

- **Whisker Loader: allows accurate measurement of contact area between pointed .005″ diameter wire and semiconductor surface. IBM Bulletin No. 300.**
- **Thimbleful of Liquid Memory: using the nuclei of hydrogen to store information. IBM Bulletin No. 301.**

For bulletins, write to Dept. 1A-9, IBM, 590 Madison Ave., New York 22, N.Y.

Whisker Loader

Transistors are a "natural" for computers because of their small size, long life, and lower power needs than vacuum tubes. While most transistors used today are of the junction type, some applications require the point-contact type. In this type, the desired trace element is introduced into the germanium "heart" by

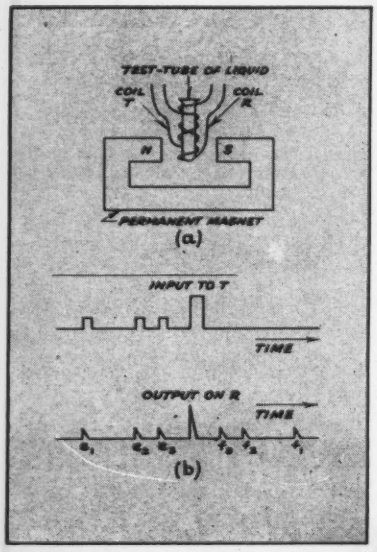


passing a large pulse of current through the pointed wire—which contains the desired trace element and which is in contact with the germanium. The result: heat causes the element to penetrate—or diffuse into the germanium. An important problem in the development of a manufacturing process for this type of transistor was to determine—one at a time—the influence on the diffusion process of each of the various factors involved. Jim Hanson, of our Poughkeepsie Research Laboratory, tackled this problem and came up with some of the answers by using what he calls the Whisker Loader. This precision instrument which he developed makes it possible to place the point of a five one-thousandths inch diameter wire upon the germanium surface; momentarily press the point against the surface with an accurately determined force of several grams; remove the wire and measure and inspect the area of contact between the wire and the germanium with a microscope (as small as one hundred-millionth of a square inch); and then replace the wire on the germanium, in the same position it first occupied, for electrical pulse forming. Our knowledge and understanding of pulse-forming techniques have been greatly increased by the use of this instrument.

A full report that clearly details test procedures, test results and other pertinent data is available in IBM Bulletin No. 300. Write for your copy.

Liquid Memory

Put a small amount of liquid such as glycerine in a d-c magnetic field, apply radio frequency pulses, and one can obtain radio frequency "echoes" of the applied pulses! This is the essence of the spin-echo effect which has been used by IBM scientists to store information in liquids containing hydrogen nuclei. By proper combinations of r-f pulses, hundreds of echoes in "mirror order" or in "normal order" can be obtained. Referring to schematic below, when a liquid containing hydrogen—such as water or glycerine—is put into the test tube and pulses of r-f current are applied to coil T, pulses will be produced across the terminals of coil R as shown. The pulses e_1, e_2, and e_3 are found only if pulses f_1, f_2, and f_3 have been applied and hence are called "echoes."



The effect may be understood in terms of the magnetic moments and angular momenta or spins of the hydrogen nuclei. In the d-c magnetic field, the nuclear moments are aligned so that the net moment throughout the sample is parallel to the field. A weak r-f pulse tilts the net moment away from the d-c field, about which it then precesses. But, due to inhomogeneities in the field, moments in different parts of the sample process at slightly different rates . . . get out of phase with one another, and hence cannot be detected. The strong r-f pulse rotates all of the moments so that those which were farthest ahead in phase become farthest behind, and conversely. Subsequent precession brings the moments back into phase, giving rise to the echo signal.

A research group at the IBM Watson Laboratory in New York City, headed by Robert M. Walker, has investigated this effect and succeeded in storing a thousand "bits" of information in a thimbleful of liquid. Some day this form of memory may be an important component of a computing machine.

This method of storage based upon the principles of free nuclear induction is more fully described in IBM Bulletin No. 301.

To learn more about career opportunities available at IBM, write, describing your background, to: W. M. Hoyt, IBM, Room 3609, 590 Madison Avenue, New York 22, N. Y.

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For more information circle **158** on inquiry card.

Automatic Data Reduction

Automatic data reduction becomes essential when large quantities of data must be handled. Considerations in selection of an on-line system include (1) required accuracy of conversion, (2) required number of channels, (3) bandwidth per channel, (4) suitability of output for following computer equipment, and (5) method of recording. Advantages of motion-picture-film recording of data are emphasized.

MARTIN L. KLEIN
FRANK K. WILLIAMS
HARRY C. MORGAN
Rocketdyne Div.,
North American Aviation, Inc.

IN most industrial processes it is customary to record data from various process points simultaneously. These points represent various variables: pressure, temperature, pH, valve position, and so on. These are recorded as functions of a common independent variable, usually time. Often, when the process proceeds according to plan, the data are merely filed or destroyed, being of no subsequent use. Other times they are used to determine where the process has gone wrong or to analyze the basic nature of the process. In purely experimental work, for example in wind-tunnel testing, data are accumulated solely for investigative work; it is not uncommon to simultaneously record pressure data from several hundred points, thus obtaining a pressure profile of the aerodynamic body under study.

It is evident that the accumulation of large quantities of experimental data results in a problem in data reduction—the correction of the data, the reading and scaling of the data, and their application to formulas for computation.

Present Techniques

Ordinarily, data are accumulated in analog form in which each point is recorded continuously as a function of time. This results in substantially the following steps between the analog record and the desired computation:

1. Read data and convert to digits
2. Scale data to full scale of instruments
3. Make additional corrections for nonlinearity
4. Record corrected data in digital form
5. Apply to computational formulas

In simple experiments, this task is not particularly tedious. However, in the simultaneous accumulation of a multiplicity of points this can become an enormous task; it is not uncommon to find groups of twenty or thirty people involved in performing these operations for the data output of a single wind tunnel. Further, human readout or computation involves certain inherent errors; it is impossible for a hundred points to be read from a curve or analog trace and converted to digits without a reading error. Even if the operation is repeated (a wasteful operation) the errors remain or new ones occur. At its best, human readout and computation is inefficient and unreliable.

Some thirty years ago the first of the automatic calculators was applied to handling of digital data. Steps 2 to 5 in the previous list of operations in reducing data were performed automatically. Thus, if it were possible to obtain data directly on, say, punched cards, it would be entirely possible to use mechanical devices to make the required computations and data sorting with minimum effort and maximum accuracy.

This is substantially the operations adopted by accountants in keeping business records, and the flexibility of these computing machines and systems, such as National Cash Register, IBM, and Remington Rand, among others, have long been considered standard operating procedure by accountants for handling financial, production, and statistical information. It is evident, then, that if data could be accumulated from the experiment being performed directly in digital form, as on punched cards, the data could be processed in a similar manner. The final step for completely automatic data reduction is the obtaining of all data in digital form from transducers which ordinarily produce analog records of the phenomenon being measured. In other words the human operator in Step 1 of the series of operations listed also should be replaced.

Manual Handling of Data

The steps for manual reduction of data are shown in Fig. 11-1. The input data are assumed to be analog in

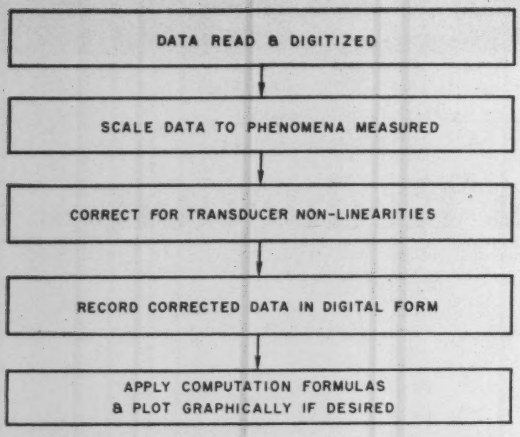

DATA READ & DIGITIZED
SCALE DATA TO PHENOMENA MEASURED
CORRECT FOR TRANSDUCER NON-LINEARITIES
RECORD CORRECTED DATA IN DIGITAL FORM
APPLY COMPUTATION FORMULAS
& PLOT GRAPHICALLY IF DESIRED

Fig. 11-1. Steps required for manual reduction of data of analog nature.

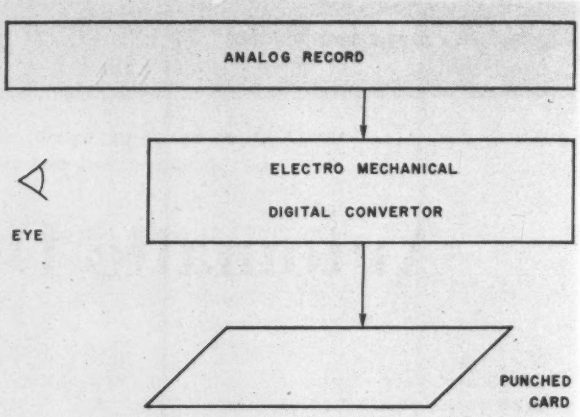


Fig. 11-2. Optical technique for converting analog-type data into punched-card data requires the alignment of two cross hairs over the analog trace. Pressing a button causes a card to be punched with a code representing the value of the variable.

nature and are obtained either as inked records or photographic records as a function of time. It is also common to record full-scale readings for each trace before and after the data are accumulated; this is used to scale the data to its corresponding value.

The first step is for the operator to read the data and convert them to digits at fixed intervals of time. This is a tedious and inaccurate operation and depends on the operator's eyesight, interest, and memory. The rate at which this can be done is incredibly slow, averaging about one digitization and recording every four or five seconds for short intervals.

The second operation is to scale the numerical data obtained to the corresponding pressure by multiplying by a constant scale factor. Thus, if full scale for a given transducer is two inches, and this corresponds to 1000 psi of pressure, the raw data read off the curve are linearly scaled and converted—a 1″ reading is converted to 500 psi, a ½″ reading becomes 250 psi, and so on. This is the raw and uncorrected data scaled to represent the output of the transducer in terms of the measurement being made. The second operation might include corrections for nonlinearities in the transducer. Thus a reading of 250 psi might be further corrected to 264 psi by reference to a table of values or calibration curve. This introduces further errors.

Finally, the corrected data are inserted into a formula for computation by hand, slide rule, multiplication tables, or desk top computer; the individual readings are used point by point. The computed value could be replotted, if desired, to obtain an analog curve of the results. Surprisingly, this is the most common method, even today, of interpreting data. If these operations were multiplied by the hundred or so points per station and the several hundred stations involved, the operations would be repeated over ten thousand times for a given run. It is perfectly possible, then, to eventually occupy every human being in the country in the reduction of experimental data.

Semi-Automatic Techniques

Some progressive organizations have mechanized these operations partially. One technique is obviously the automation of steps 2 to 5 listed previously. After the curve is read and converted to digits by manual methods the results are hand-punched into cards for automatic computers of the type mentioned. Although steps 2 to 5 are made automatic, step 1 requires the reading of points at fixed intervals by eye and then punching the tabulated data for each point onto cards.

An alternate procedure, shown in Fig. 11-2, makes use of existing commercial equipment in eliminating step 1. Here the analog data are converted directly into a punched card. The equipment available still depends on the eye and accuracy of the human operator in aligning two cross hairs over the analog trace. He then depresses a button and the card with the raw data is obtained. The machine is previously scaled so that full scale for an analog trace is pre-set, say, at 1000 counts. The punched cards obtained are then available for automatic computation. This entire semi-automatic system is shown in Fig. 11-3. In many installations where the quantity of data is not too large, this semi-automatic method is certainly the best technique for handling large quantities of data without extensive equipment.

On-Line Data Reduction

The previous methods of data reduction are of the post-operative type—that is, the data are first recorded in analog form and then, after the experiment is completed, converted into digital form and computations made. An alternate method for reducing analog data to digital form is to perform the digitization simultaneously with the experiment. This is called *on-line data reduction*. As fast as the analog data are obtained, they are converted to digital form and all recording and subsequent operations are then in digital form. This is, unquestionably, the optimal method for handling data because the human operator is eliminated and the accuracy depends only on the equipment used.

It is possible to use a digital transducer to obtain digital data directly. However, as most organizations are committed to analog transducers and as digital transducers are not always available for all variables, it will be assumed that data are obtained from the transducer in analog form.

If we are to obtain on-line digital data, we must consider several basic questions. Among the principal ones are:

1. Accuracy of conversion.
2. Number of channels of data.

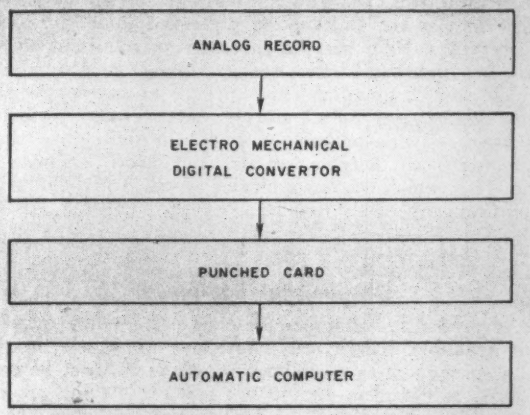


Fig. 11-3. Semi-automatic data-reduction system using analog-type input, electro-mechanical conversion to punched cards, followed by automatic computation.

3. Bandwidth per channel.
4. Machine on which computations are to be made.

Accuracy of Conversion

The conversion accuracy depends on the accuracy required for the experiment. Once the data are obtained in digital form, further errors are eliminated, but one must determine in advance at what accuracy the conversion is to be made.

Accuracies in excess of 0.1% are difficult to obtain in present converters. Another limiting factor exists which makes even 0.1% accuracy questionable—the transducer accuracy. Although some transducers are capable of 0.1% accuracy as *static reading* devices, doubt exists whether they are genuinely 0.1% accurate in *dynamic readings*. It is possible to design a converter to 0.1% and yet obtain dynamic data from the transducer which are not even 5% accurate. This is an important practical point.

Another point concerns data linkage. Digital or analog data are customarily transmitted from the transducer to the recording point over long transmission lines. Any technique for data transmission (including pulse code and f-m techniques) is hardly accurate to the 0.1% accuracy many investigators believe they are obtaining. In light of the above, practical converters with better than 0.1% accuracy may not even be necessary.

Choice of converter is somewhat optional; each of the three basic electronic techniquess—space, time, or feedback encoding—is capable of equivalent accuracy, depending on the complexity of the equipment. The choice of whether mechanical or electronic converters should be used depends on the *rate of conversion*, which depends in turn on the number of channels and the bandwidth of the channels.

Number of Channels

The number of channels from which data are to be obtained is another consideration of importance. It is no more difficult to convert on-line from 100 channels than it is for 10 channels; the properly designed system can handle any number of channels without difficulty. However in a multi-channel multiplexed system, the conversion rate and stepping rate of the scanner or multiplexer depends entirely on the number of channels to be read. This factor usually establishes whether a mechanical or electronic system is to be used, as shown by the following examples.

Suppose we wish to investigate a system of 100 channels, and to take a single reading from each channel every 10 seconds. This might be a slow chemical process or fermentation process where faster recording of data is wasteful. As each channel is to be read every 10 seconds, and as there are 100 channels, the scanner must step at the rate of 10 channels every second. Similarly, the converter must make its conversion at a rate of 10 conversions per second. This is well within the possibilities of an electromechanical system; relays or other electromechanical devices could be used.

However, suppose we wish to record data from the same 100 channels at a rate of 10 readings per second *per channel*. This means the multiplexer must make 1000 steps per second, and the converter must be capable of converting at this rate of 1000 conversions per second. This is far beyond the capabilities of electromechanical systems; an electronic system is required.

It should be pointed out also that an all-electronic system can be slowed down with ease to as few conversions per second as the slowest mechanical system, but the mechanical systems using the latest crossbar-switch techniques have an optimal speed of only 100 steps per second. For this reason, greater attention is being directed toward all-electronic data-reduction systems.

Bandwidth per Channel

In the chapter on "Information Theory," it was pointed out that the bandwidth is directly related to the number of points per second read from a channel. This is important because bandwidth (rise time) as well as the number of channels, dictate the type of system to be used. In other words, a highly accurate (0.5%) system with few channels and narrow bandwidth (slow rise time) can be handled by a relatively slow system; however, even an inaccurate (5%) wide-band fast-rise-time system ordinarily would require fast equipment, even for a few channels of information.

The computation is roughly the same as the previous one. Suppose, for example, that we choose to read two channels with the following specifications:

Channel 1: 500 cps, 5 points per cycle, 1%
Channel 2: 100 cps, 5 points per cycle, 0.1%
Type of encoder: Time encoder, 50% duty cycle with phantastron sweep.

Channel 1 requires converting of 2500 points per second; Channel 2 requires 500 points per second. The total conversion rate required, then, is 3000 points per second.

The multiplexer must step at this rate, and we arrange to patch the input to the multiplexer so that 2500/3000 of the time is spent on Channel 1 and the balance (500/3000 of the time) spent on Channel 2. In other words, we divide the multiplexer in proportion to the number of points to be taken from the channel.

The converter specified was of the time type which requires a 50% duty cycle for proper operation. This means that each conversion must be made in a time not greater than ½ of 1/3000 second, or 1/6000 second.

Note that the accuracy requirements for the two channels are different. As the converter is to be multiplexed among the two channels, it must be capable of the highest accuracy required by any channel, here 0.1%. On the 1% channel we have higher accuracy than is needed, but it is more economical to multiplex the converter and waste part of the accuracy part of the time. Accordingly,

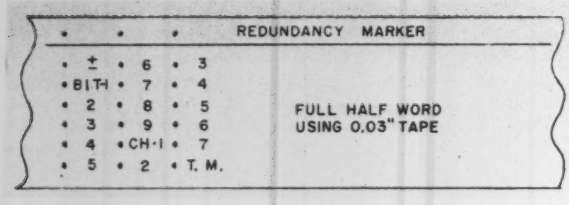


Fig. 11-4. Data on tape for an IBM 701 Computer. Each vertical line has six information tracks and one check track (at top).

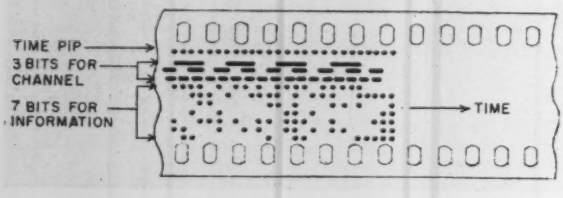


Fig. 11-5. Digital film record for the North American Aviation IDIOT I data-reduction system. One vertical reading gives time (top bit), channel identification (3 bits), and data (7 bits).

we must have 1000 counts and this must be made in 1/6000 second in the converter of the time type. Accordingly, the converter flip-flops have to run at a rate of 6 megacycles per second. This is near the limit of flip-flop operation, in fact of pulse techniques, at present. The preceding example can be extended to any number of channels as a basic design for the system to be used.

Note also that if a feedback encoder is used the duty cycle can be made 100% and we can cut the counter rate. This suggests that a time converter is probably not the best choice.

Machine on Which Computations are to be Made

The computing machine used for the data reduction dictates the method of recording the data. Recording data on tape is usually most efficient for digital data. Punched-card input is inefficient because card data are usually transferred to tape before other computations take place. This transfer is also a time-consuming operation on a computer (which can cost up to $30,000 a month to rent).

Further, various machines have different tape codes so this must be taken into consideration if data are to be recorded directly on tape. For example, the data on tape for feeding an IBM 701 Computer is shown in Fig. 11-4. Here a parity check (redundancy bit) is added in the 7th channel and this must be placed on the tape if the machine is to read the digital data directly. This tape would not necessarily operate a computer of different manufacture. The IBM CPC 626 system works only from punched cards and, in this case, data must be available in card form and tape is of no interest.

Another recording problem has to do with *storage properties*. The long-term storage properties of cards are satisfactory, but if appreciable data are accumulated the storage space required for cards is a problem. Insofar as tape is concerned, the long-term storage properties of tape are not known, though presumed good. It is perfectly possible that transfer from one layer of data to another will invalidate the records over a period of, say, ten years. This is not yet established because digital tapes are not that old.

As a compromise medium, *motion-picture film* appears to be promising. Data, as you know if you have watched 1924 movies on TV, can be preserved intact for over thirty years. Film has the space-saving requirements of tape but does require processing, which is now relatively simple and automatic. This appears at present as the most logical method of storing data despite the extra operation of film processing (which in digital recording is non-critical). A typical digital film record is shown in Fig. 11-5, which was made on the North American Aviation Company's Data Reduction System known as IDIOT I.

Commercial Equipment

At present, several commercial on-line data systems are available. There are many systems which process data subsequent to recording, but these will not be considered as complete automation systems. At the present rate of progress there should be over two dozen commercial data handling systems available within two years.

A brief account of North American's system will be given because it is the one with which the authors are most familiar, both in design and field operation. This system is known as IDIOT.

In designing this system, consideration has been given to the previous points and to the fact that many uses will be brought up which have not been anticipated. Accordingly, while it is far from an optimal arrangement, it is flexible and can be applied either as a data-reduction or, with feedback, as a control system, or both simultaneously.

IDIOT

This data-reduction system has been designed in three versions. The first of these uses a *time encoder* for conversion, the second a *feedback encoder* (using a magnetron tube), and the third a *spatial encoder* making use of a monoscope tube. In many applications, the types of converter are interchangeable, but auxiliary requirements may dictate one or the other type. Each of the converters has been described in detail in the previous chapter on Practical Converters, and coupling methods for the various component circuits have been described in the chapter on Circuitry. The IDIOT chronometric encoding version will be described as representative of a typical commercial data-handling system.

The various operations are shown in block form in Fig. 11-6. Eight input channels are available; each is presumed to be 0 to 100 millivolts full scale. Transducers with higher outputs are scaled down, and those with lower outputs are amplified with suitable equipment such as chopper-stabilized amplifiers.

The *multiplexer* steps at a rate of 1,000 steps per second from one input to the next. Thus, if eight separate channels are used, each channel is sampled every 1/125 second. The signals from the various inputs are in turn *clamped* (held at a constant value) for the conversion period, then the clamp is allowed to examine the next channel. The sampling interval of the clamp is 5 microseconds and the clamp averages the input signal for that interval of time. This average is used as the value for the input during the entire sampling interval of 1/1000 of a second.

According to information theory, if we allow two samples per cycle, a measure of the entire information content of a 62.5-cps signal is obtained. Thus each of the eight channels has 62.5 cps of bandwidth and input filters of 62.5 cps are used.

It is also possible to distribute the total 500 cps of

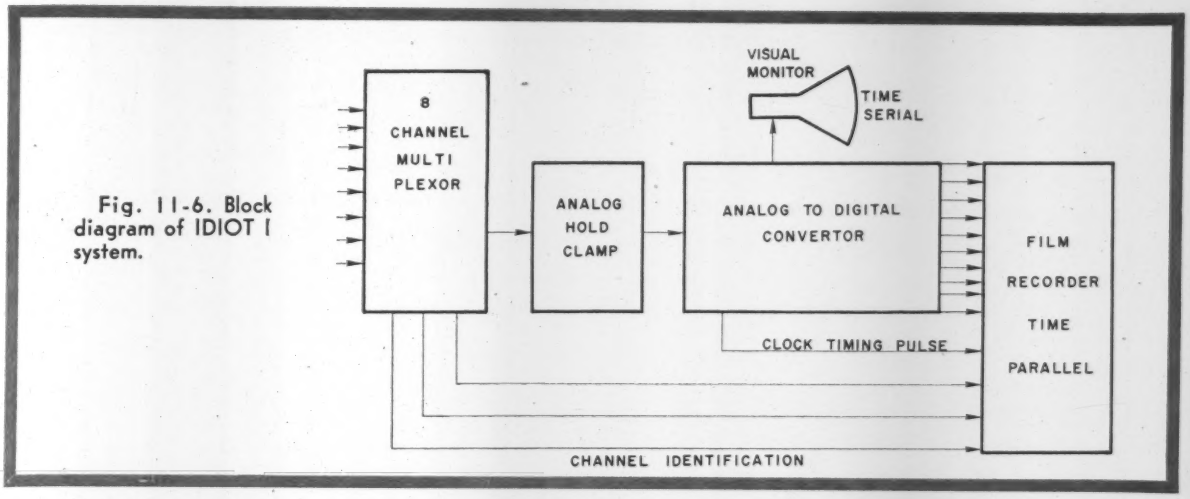


Fig. 11-6. Block diagram of IDIOT I system.

bandwidth (8 channels x 62.5 cps/channel) in any way desired. Thus, with a single input patched to every point of the multiplexer, the single channel would require a 500-cps filter for optimal operation. It should be noted that there is flexibility in distributing the multiplexer among the input signals.

After the signal is clamped and the conversion made, the output is obtained in series form, or serial time. This can be used for visual monitoring on an oscilloscope and is the digital output of the analog signal. The multiplexer also sends a binary coding of which channel is being read for identification of the signal. This is recorded next to the digitized reading of the channel.

The serial pulses from the converter are sent to a temporary storage in which they become *time parallel pulses.* From an internal key pulse, the digitized reading and the channel identification are used to illuminate a bank of 13 neon tubes, 10 of which are used for information—one for each bit and three for each bit representing the eight channels. This is flashed on for 1/10,000 second and recorded by a shutterless motion-picture camera which pulls 35-mm film from a 400-ft magazine. The film travel is arranged to space the readings 15 to the inch. We have now a digital recording of the information plus the channel identification on 35-mm motion picture film. This can be processed in five minutes and the picture shown in Fig. 11-5 (which is a 7-bit system, 1% resolution) is obtained.

The system also provides an internal check of the conversion. This requires that the digits be reconverted on-line with the conversion to an analog signal. This is done by putting the time-parallel information pulses back through a weighting network and summing the voltages as described in the chapter on Digital-to-Analog Converters. The sum voltage is, if the conversion is correctly made, exactly equal to the voltage clamped before conversion. These two voltages are compared; if they agree within the accuracy of the converter, here 1.0%, the reading pulse mentioned transcribes the results onto the film. If they do not agree, an additional error mark is placed on the film, which is used later on readout to ignore the reading. This is a positive check that the whole system is operating correctly.

In addition, one of the input channels can be driven by a standard cell; thus a positive check is made that the entire system is not drifting. This self-checking feature cannot be accomplished by human readings because it has been shown that errors have crept through as many as ten successive checks by human operators checking each other's readings of a curve and transcribing the curves to digits.

This reconverted analog signal is channeled also to a decommutator, and the various channels fed out through separate lines. Each line represents a single channel, or in the event that one input channel occupies two or more inputs, the decommutator can be patched correspondingly. We thus separate the output analog signals into separate lines representing the information of the sample in the clamp. This value is held in a decommutator clamp and recorded by analog instruments as representing the analog value until the next sample comes through from the same channel. Thus, by a series of plateaus, we represent the analog signal and, of course, the faster the conversion rate the more accurately the plateaus represent the correct analog signal. Thus, it is possible to obtain, on-line, the following:

1. Digital data and channel identification.
2. Analog data from the input to the converter.
3. Analog data from the reconverter made by first converting to digits and reconverting.

For interest, we include traces (Fig. 11-7) recorded from the input analog signal. These were made by first converting the input to binary digits and then reconverting the digits to analog form as described.

Fig. 11-8 shows a block diagram of a system for reading the motion-picture film with the recorded digits. It is run through a 35-mm motion-picture projector which projects the film onto a bank of photocells. As the identification

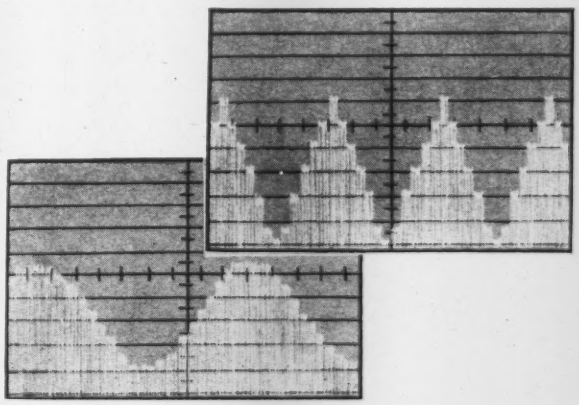


Fig. 11-7. Analog reconversion of 50-cps sine wave (left) and 50-cps triangular wave (right).

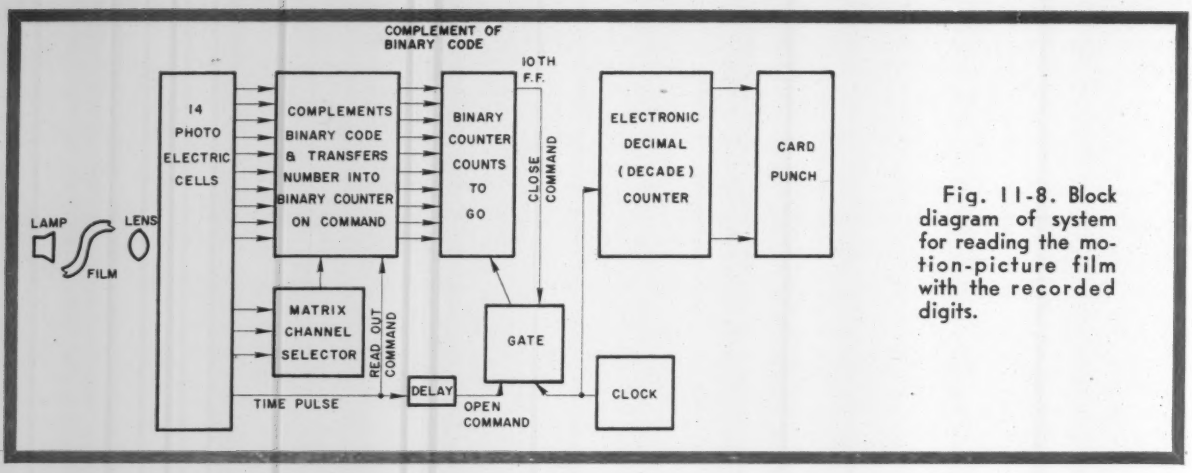


Fig. 11-8. Block diagram of system for reading the motion-picture film with the recorded digits.

of channel is included, a channel selector allows one channel at a time to be read. As the identification pulses pass the photocells for the channel selected, a pulse reads the photocells on which the information bits are projected. This reading is transferred to a binary storage and is then converted into a decimal number using a unique binary-decimal conversion technique which was described in the chapter on Digital-to-Analog Reconverters. This reconverted decimal count is held in storage in a commercial decimal counter and then the count is transferred with an auxiliary commercial unit to punched cards. It is also possible to punch the cards directly in binary.

As an alternate, the film can be read into the storage shown and then converted into binary code for the IBM 701 (where the code was shown previously in Fig. 11-4). The circuit used also places a redundancy code mark on the tape and spaces the marks 1/100 of an inch as required by the IBM 701.

The film can be pulled slowly and read with a photocell bank; such slow-speed readout is difficult with tape recording because slowly moving tapes require either flux reading heads or vibrating heads or boundary displacement heads to develop sufficient voltage for reading. These difficulties are avoided in this system. Film also provides the advantage of allowing visual examination of the information at any time; this is not possible with tape.

This complete data-handling system is capable of high conversion speeds from a multiplicity of channels and provides (1) self-checking beyond human capabilities, (2) analog output, and (3) digital recording for punched cards, Flexowriter tape, or magnetic tape for computer use.

Table 11-1. Characteristics of IDIOT Systems Types I, II, and IV

	Type I	Type II	Type IV
Channels	8	128	256
Accuracy	1.0%	0.1%	0.5%
Resolution	1/128	1/1024	1/256
Encoding Technique	Time	Feedback	Monoscope Tub (Space)
Conversion Rate	2500/sec. max.	100,000/sec. max	5,000,000
Recording Medium	Motion Picture Film	Magnetic Tape	None
Input Signal Level	100 mv. max.	100 mv. max.	1.0 volt

Using IDIOT for Process Automation

The data-reduction system can be used also as a feedback loop for a process automation system. The instrument described senses the input of up to several hundred transducers and converts them to digits. If the digital information is fed to a comparison and command network which is programmed as described in Chapter 9, the forward-going command operations of an automation system are completed. Auxiliary equipment would consist principally of diode matrices and power handling tubes.

Basic quantitative knowledge of a process is necessary for automation of a system. The advantage in using a data-handling system is evident. In many applications, this information has yet to be obtained with a data-reduction system. At the time when knowledge of the process is obtained, the system can be expanded in module fashion and the comparison and command logic equipment added to complete the automation of the system.

Another advantage of using such an all-electronic system is that data can be recorded with wide bandwidth. Although most processes require only small bandwidth response (few samples per second) for the various instruments, the equipment can be modified simply to operate at the slower speeds required. Even after complete automation is instituted, the equipment can act also as a recording medium for the data used in either digital or analog form. Thus, a complete system can be built, step by step, until a completely automatic system both in operation and data recording results.

Summary

We have examined a data-reduction system and its advantages in handling large quantities of data. The basic design requirements for the system were pointed out. A sample system was analyzed and, in particular, the operations that a data handling system should perform were outlined. It was shown that this is essentially the feedback loop of a digital automation system and that by proper design, after the data is used to obtain quantitative information about the process, the system can be expanded to automatically control the process. This has the advantage of not making any existing equipment obsolete.

Fig. 1. The new Bendix Computer Model G-15D provides, in one integrated system, a versatile general-purpose computer in combination with a digital differential analyzer.

The G-15 Digital Computer

Here is a clear and thorough introduction to the principles, operation, and application of the general-purpose digital computer of moderate size.

S. Herbert Lewis
Bendix Computer Div.
Bendix Aviation Corp.

PROGRESS in technology is always accompanied by developments in language, because new devices have to be named and new processes described. Sometimes new words like *automation* or *transistor* are invented, but more often old words like *memory* or *program* are applied with new extensions of meaning. It is hoped that some of the mystery may be removed from the jargon associated with automatic digital computers by a description of the Bendix Model G-15: what it is, how it works, and where it can be used.

The first step toward a realistic understanding of what a machine like this is supposed to do for you is to dispose of the misconceptions created by such journalistic gobbledygook as *giant brain, electronic wizard,* and so on. These tricky names lead you to expect a computer to be some kind of a supernatural gadget that not only understands all your problems but knows how to solve them; whereas it is actually a practical and useful tool, one that will perform efficiently just the tasks planned for it by an intelligent human who does all the thinking beforehand. You don't have to be a genius to learn how to use this tool, but you must know enough about your problem and the procedure for solving it to prepare a detailed set of directions for each operation the machine is to perform.

An automatic digital computer is designed to execute a sequence of the operations of ordinary arithmetic, to make simple decisions, and to record the results in a useful form. A *general-purpose* computer will handle a virtually endless variety of problems whose solution can be reduced to a succession of these basic operations. Some general-purpose equipment is well suited for payroll calculations, inventory control, and other commercial applications where bulky data must be processed rapidly with relatively little arithmetic at each stage. Other computers in the general-purpose category, like the G-15, are better adapted to problems like those in engineering and the sciences where a smaller amount of data leads to a larger volume of calculations.

A *special-purpose* computer, on the other hand, is intended for much more restricted application to only one task, or at best to a severely limited class of jobs. For example, the Bendix Digital Differential Analyzer, Model D-12 is designed for the rapid and accurate solution of differential equations. Yet a general-purpose computer may be regarded, temporarily, as a special-purpose machine while it is engaged in a specific assignment, al-

Presented at Second Computer Clinic, Second International Automation Exposition, Chicago, Ill., 1955.

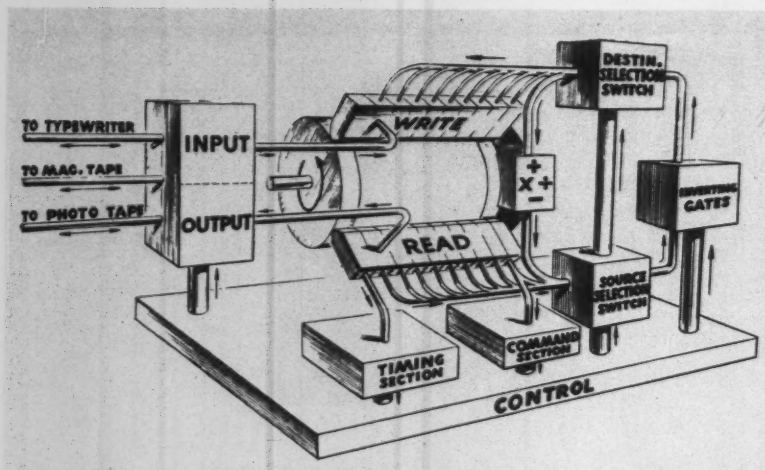


Fig. 2. Schematic representation of the major functional components and paths of information flow in the G-15.

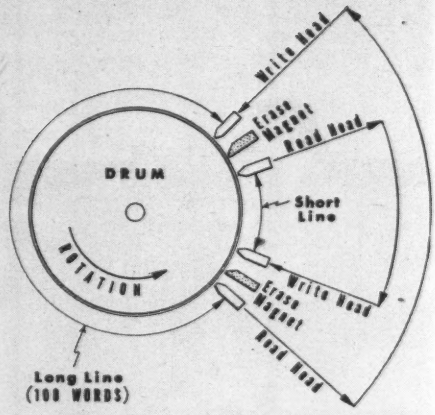


Fig. 3. Cross section of the G-15 magnetic drum. Each of 20 "long" lines, or circumferential tracks, contains 108 words of 29 bits. Rapid-access storage consists of four "short" 4-word lines; the arithmetic registers are a 1-word line and three 2-word lines. The read and write heads for the shorter lines are staggered between those for the long lines.

though no hardware need be modified to change its application from one problem to another.

The flexibility of a general-purpose computer is combined with the special advantages of a digital differential analyzer in the new Bendix G-15D, now in production. The versatility of the basic G-15, described here, is extended by the addition of an optional auxiliary unit, Model DA-1, for special applications.

Computers are commonly classified as either *digital* or *analog* devices. In the latter, the variations in a physical quantity (such as the pressure of a gas or the velocity of a rotating shaft) are represented by continuous changes in some other quantity (a voltage, for example). The components and behavior of the real or proposed system under study are analogous to those of another system which may be regarded as a model. In digital computers, which deal only with numbers, the model is mathematical and the behavior of a physical system is determined by the results of operations in arithmetic.

Therefore, describing the Bendix G-15 (Fig. 1) as a *general-purpose digital computer* implies that it is a mathematical tool applicable to widely diversified tasks involving manipulations with numbers. To understand how the computer works, you should know something about various ways in which numbers can be represented.

Number Language

Probably because ten fingers are standard human equipment, and because counting or tallying on the fingers comes naturally, we have become accustomed to representing numbers by a set of ten characters or symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9. The derivation from finger counting leads also to the term *digit* for any one of these symbols, and because there are ten digits the notation is called *decimal*.

Another familiar notation, Roman numerals, employs alphabetical characters. Although satisfactory for counting years or chapters, this scheme is seen to be too awkward for arithmetic when you try to add MCMXIV to DXLVIII.

However, not even the decimal system is the most propitious when numbers are to be portrayed and manipulated by magnetic or electronic equipment. Design is simpler and components fewer when advantage is taken of the opportunity to represent numbers with elements that can have only two different values instead of ten. It is easy to recognize that a voltage is either relatively high or low, that a current is either flowing or not, or that a magnet moves either north pole first or south pole first. If the voltage, for example, is low at a particular time, this condition may be denoted by "0"; if the voltage is high, that state is described by "1". With these two symbols we have a *binary* number language. The binary digits, 0 and 1, are called *bits*—an abbreviation for "binary digits."

Any number can be expressed in binary (bit) form, as shown in Table 1. There are two basic advantages in expressing numbers in this way—(1) simple elements can be used to indicate each of the bits in the binary number, as has been mentioned, and (2) arithmetic is surprisingly easy when numbers are expressed in binary form. For example, we need remember only these two simple rules for performing addition:

Rule 1. 0 plus 1 is 1
Rule 2. 1 plus 1 is 0 and carry 1 to the next column left.

With these two rules let us add 10 and 11 (binary numbers equivalent to the decimal numbers 2 and 3):

```
  10
  11
 ---
   1
   0      carry 1 left
   1      the carried 1
 ---
 101
```

The binary 101 is equivalent to the decimal number 5, which is indeed the sum of 2 and 3. It is obvious that a computer that is required to "remember" only these two basic addition rules will be much simpler than one that must "remember" that the sum of 3 and 4 is 7, or 4 and 8 is 12, plus all the other rules for addition with decimal numbers.

For similar reasons, subtraction and multiplication are also much simpler in the binary system because fewer combinations are possible. For example, multiplication is performed with only the two following rules:

Rule 1: 1 x 0 is 0
Rule 2: 1 x 1 is 1

Table 1.—Decimal Numbers and Binary-Number Equivalents.

Decimal	Pure Binary
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1
10	1 0 1 0

Let us multiply the same two binaries, 11 and 10:

$$\begin{array}{r} 11 \\ 10 \\ \hline 00 \\ 11 \\ \hline 110, \end{array}$$

which is indeed equivalent to binary number 6.

It must be remembered that a given number or the result of an arithmetic operation is the same, whether it is expressed in the decimal system whose *base* is ten or in the binary system whose *base* is two. Any number, integer or fraction, can be depicted by a succession of bits, with a *binary point* separating the integral part from the fractional. The number of places a binary digit is removed from the binary point indicates the power of two it contributes, just as the position of a decimal digit signifies a power of ten. For example, the binary number 10.01 equals

$$1(2)^1 + 0(2)^0 + 0(2)^{-1} + 1(2)^{-2} = 2.25$$

Binary-Coded Decimal

All arithmetic in the G-15 is performed on binary numbers. However, it would be too laborious to translate decimal numbers into the binary language before they are fed into the computer, so the conversion is accomplished automatically in two stages, using *binary-coded decimal* numbers.

A binary-coded decimal number expresses each digit in the decimal number in binary form. For example, the decimal number 22 in binary-coded decimal is 0010 0010, where each of the four-bit binaries is equivalent to the decimal number 2. Similarly, the number 99 in binary-coded decimal is 1001 1001. As four bits are required to express the largest number (9), each decimal digit is expressed as a group of four bits. The second column in Table 2 shows some equivalent representations of numbers in binary-coded decimal.

In the G-15, each decimal digit enters the computer, in the form of its binary equivalent, as a group of four bits. Then the intermediate *binary-coded decimal* representation is converted to true binary. A reverse procedure permits binary results to be obtained in decimal form.

Sexadecimal Notation

Sometimes a record is wanted of the unconverted binary contents of the computer. Then a kind of shorthand is used which involves a number system with a base of *sixteen* instead of two or ten. This base is used because each group of four bits, as used for binary-coded decimal, can represent 16 different numbers (0 to 15). By assigning a symbol to each of these combinations we arrive at a notation called *sexadecimal* (usually *hex* in conversation because nobody wants to abbreviate *sex*). The symbols in sexadecimal language are the ten decimal digits and, on the G-15 typewriter, the letters u, v, w, x, y, z. These are arbitrary markings; some other computers use different alphabetic characters.

Table 2.—Equivalent Representations of Numbers.

Decimal	Binary-coded Decimal	Binary	Sexadecimal
0	0000	0	0
1	0001	1	1
2	0010	10	2
3	0011	11	3
4	0100	100	4
5	0101	101	5
6	0110	110	6
7	0111	111	7
8	1000	1000	8
9	1001	1001	9
10	0001 0000	1010	u
11	0001 0001	1011	v
12	0001 0010	1100	w
13	0001 0011	1101	x
14	0001 0100	1110	y
15	0001 0101	1111	z
16	0001 0110	1 0000	10
17	0001 0111	1 0001	11
18	0001 1000	1 0010	12
19	0001 1001	1 0011	13
20	0010 0000	1 0100	14

Equivalent forms of some numbers in decimal, binary-coded decimal, binary, and sexadecimal are shown in Table 2.

G-15 Major Functional Components

The organization of an automatic computer, like that of any other machinery, is dictated by the purpose to be served. There are, in general, two classes of jobs for which this apparatus is intended. One consists of problems involving such long and tedious calculations such that solution by other means is not even feasible. The other includes computations that have to be repeated frequently with different sets of numbers. In either case, speed and the utmost reliability are essential. Furthermore, a general-purpose computer must possess a versatility that permits its adaptation to a variety of tasks. The components of various machines differ in design and operating principles, but most have the common functions exemplified in the G-15 as depicted schematically in Fig. 2.

Input Devices

Obviously the numbers involved in the operations a computer performs must somehow be fed into the machine. Standard G-15 input equipment includes an *electric typewriter* (specially modified) and a *photoelectric reader* which accepts 200 characters (sexadecimal digits or special control symbols) per second from punched paper tape. Permanent records of intermediate or final results of computations may be obtained by automatic operation of the typewriter at about eight characters per second, or by a tape punch unit at somewhat higher speed. Up to four units, available as optional auxiliaries, provide for magnetic tapes as input or output media.

Memory with Recirculation

At the heart of any automatic digital computer is some device in which numbers can be retained to become available when needed in the course of calculations. This component, called the *memory* or *store*, consists, in the G-15, of a cylinder or *drum* whose surface is thinly coated with a magnetic material. About a foot in diameter and a few inches wide, it rotates at 1800 rpm. Binary numbers are

written on its surface by magnetizing a succession of spots around the circumference, using one polarity to represent "0" and the opposite polarity to represent "1." A group of 29 consecutive bits is called a *word.*

Numbers involved in arithmetic operations in the G-15 may be either one or two words long, with one bit of the 29 or 58 used to indicate the sign (0 for +; 1 for −). A one-word number (expressed in 28 bits) can be as large as 268,435,455. A *double precision* or two-word number of 57 bits is equivalent to about 17 decimal digits. The G-15 is outstanding in its facility to perform double-precision arithmetic, thus retaining significant figures through long chains of computations.

Words stored in the G-15 memory are arranged serially on the drum in circumferential tracks or *lines* (Fig. 3). As the drum rotates, the magnetized spots in each line pass under a stationary *read head* which transmits, to other elements in the computer, signals representing the information stored in its line. Almost immediately, either the same or new signals are sent to a *write head* and recorded for another ride around the drum. Between the two heads associated with each line there is an *erase* magnet which causes the drum surface passing under it to be cleared (i.e., magnetized with the same polarity as "0"), so that new writing will not be superimposed on the old. This process of reading information at one point on the drum surface and rewriting it at another is termed *recirculation.* It leads to certain advantages in circuitry.

As one consequence of the recirculation process, it can be seen that the length of a line (that is, the number of words it contains) depends directly on the circumferential distance from the write head to the read head (Fig. 3). Thus, lines of different lengths are made possible by different spacings between heads. Since a word written on the drum becomes available only when it passes under a read head, the *access time* (delay until a desired word arrives) is less for words stored in shorter lines.

The main portion of the G-15 memory consists of twenty "long" lines, each containing 108 words. There are five "short" 4-word lines, one of which is reserved for special functions during input and output processes, the other four being available for *rapid-access* storage.

Arithmetic Registers

Arithmetic operations are performed in four *registers,* also lines on the drum, three of which are of 2-word and one of 1-word length. A number may be directed to enter the 1-word register or one of the 2-word registers, either replacing or adding to the previous contents of the line. The 2-word registers are used also in multiplication and division operations with either single- or double-precision numbers. The remaining portion of memory is occupied by lines, some permanently recorded, used for control information and timing signals by which all operations in the computer are synchronized.

Transfer

Words in corresponding positions in all lines are read and written together. One line may be selected as a *source,* another as a *destination;* a word read from the source is written in the destination. Meanwhile, all lines except the one chosen as the destination continue to recirculate, their contents unchanged. The *transfer* of a word, one bit at a time, from a source to a destination, is accomplished in 0.27 millisecond. This *word time* is the unit for measuring the duration of most G-15 operations.

As soon as one transfer has been completed, a new source and destination may be selected. The next transfer begins either immediately or when a designated word is available at the read head, and it may continue for one or more word times. Flexibility in the number of words transferred in one operation is an unusual feature contributing to the efficiency of the G-15.

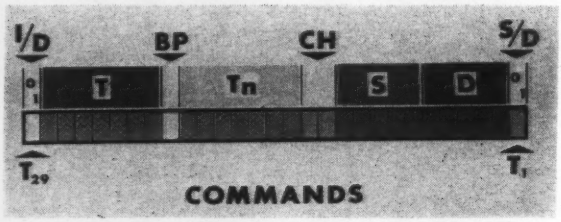


Fig. 4. A 29-bit word designated as a command. The first bit at left (i/d) signifies whether the command is immediate (i) or deferred (d). The next 7 bits (T) specify the time of operation. Tn is the location of the next command; ch is the characteristic operation to be performed; S is the source; D the destination; s/d the precision (single or double). The BP bit indicates a break point.

Commands

It is obvious that the machine, in order to function at high speed, must be controlled automatically, according to a sequence of operations established in advance. To accomplish this, the contents of a binary word can be interpreted by the control circuits as a *command.*

On being read, a command is transferred to a special register in the memory, where it is retained until the action it specifies has been performed.

Various groups of bits *within the word* are decoded to specify (1) a source, (2) a destination, (3) when a transfer starts and how long it lasts, (4) in which of certain ways words may be modified or delayed during transfer, and (5) where the next command is to be found (Fig. 4). In storage, a command can not be distinguished in form from any other word; it may even be modified arithmetically as a number. A word serves as a command only after it has been so designated by the preceding command.

Fig. 4 shows the format of the 29 bits in a G-15 command word.

i/d specifies whether the operation is immediate (i = 0) or deferred (d = 1).

T, the 7-bit "timing number," designates when a deferred operation begins or an immediate operation ends.

BP is a bit which, when given the value 1, specifies a "break point," or command after which computation can be halted automatically during program checking to examine intermediate results. Break points, though indicated, can be ignored during production runs.

T_n designates the location, or time of reading, of the next command.

ch, the transfer characteristic, determines if and how numbers may be modified or delayed during transfer. A number may be transferred unchanged, or it may be complemented if negative, or it may be made positive (absolute value), etc.

S, the source number, may specify a line or register in memory, certain logical combinations of lines, or it may serve as an operation code.

D, the destination number, either specifies a line in memory or that the source number has a special meaning.

s/d indicates single (s = 0) or double (d = 1) precision. A single-precision number consists of 28 bits and sign; a double-precision number has 57 bits and sign.

Programming

A *program*—a complete set of commands to direct the computer's step-by-step operation—must be stored in the

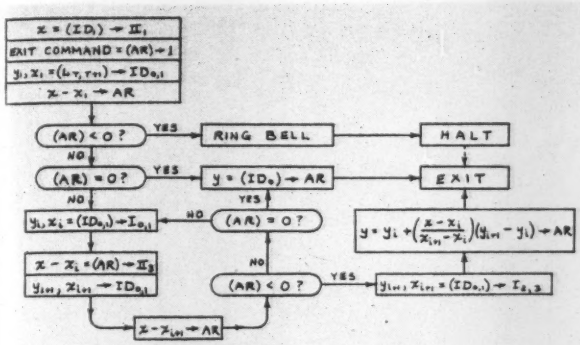


Fig. 5. Typical flow chart, showing the sequence of major steps and alternate branches in a subroutine for linear interpolation. The choice of paths at a branch point depends on conditions that arise during computation.

memory before the automatic processes begin. Therefore it becomes, in a sense, one of the functional components of the computer, along with the hardware of the input and output system, the memory, the arithmetic section, and the circuitry for communication and control.

How the Computer is Used

The automation of mathematics pays off by eliminating the duplication of effort for repetitive processes. Once a computer program has been prepared, it can be used over and over again each time the same type of problem is to be solved. The preparation of a program consists of: (1) compiling a complete and accurate statement of the problem; (2) maybe performing a numerical analysis to select suitable mathematical procedures; (3) usually drawing a flow diagram (Fig. 5) to indicate the arrangement of major blocks of commands; (4) planning the detailed steps of operation; (5) assigning locations in the computer storage for data and commands; (6) writing each command in decimally coded form; (7) finding and correcting the mistakes made in working through steps (1) to (6).

Operation of the computer itself is introduced first in step (7): the decimal commands written in step (6) are transcribed on the input typewriter and automatically converted to binary words on entry to the computer; then a tape is punched, containing the program in sexadecimal form for rapid re-entry. After the inevitable mistakes or *bugs* in the program have been detected and eliminated, little manipulation is required to load commands and data into the computer for production runs.

Subroutines and Libraries

Much of the labor required to prepare and *debug* a new program can be saved by incorporating previously checked blocks of commands called *subroutines*. These are filed in a *library* of punched tapes from which masters can be withdrawn and reproduced for compilation with other segments to form a complete program. Included in a typical library would be subroutines to convert decimal input data to binary form, and binary memory contents to decimal output; to evaluate square roots, trigonometric, and other elementary functions; to perform numerical integration, matrix operations, etc.

In addition to subroutines, which become component parts of other programs, complete *routines* are available to reduce significantly the work of getting a problem ready for the computer. Although there is no substitute for an accurate statement of the problem and a careful planning of solution methods, many clerical details can be relegated to the computer itself. A program of the type called *interpretive* permits commands to be written in a much simplified form. After a program written in the simplified *pseudo-code* has been stored in the computer, each command is read in turn and interpreted as an operation to be performed by a subroutine. Valuable savings in programming time and effort are achieved at the cost of some computing speed, a compromise which enables relatively inexperienced personnel to utilize the G-15 effectively for tasks not repeated often enough to warrant an investment in more sophisticated techniques.

Whether an interpretive routine for simplified coding is used or not, the seven steps of program preparation listed above are fairly typical, not only for the G-15 but for most general-purpose digital computers, both large and small. A closer view is in order.

It may seem unworthy of mention, or at least of emphasis, that a problem must be stated before it can be solved; but remember that an automatic machine can't ask, "What do I do now?" when it hits a snag in the middle of computation. The G-15 can make several kinds of simple decisions and, as a result, select between alternative sequences of ensuing commands; but unless the statement of a problem is initially complete, some conditions are likely to be overlooked. Not only must equations be written to express the relationships among the quantities involved in a computation, but every conceivable situation must be anticipated and its consequences set forth explicitly.

In some types of problems there is little or no uncertainty about the best method of solution; in others, however, various formulas or numerical techniques may be available. There are several good ways, for example, to approximate the solution of a set of differential equations or to invert a matrix; and each procedure has features to recommend it in certain instances. In these cases, depending more on the character of the problem than on the details of the computer, the application of the mathematical techniques of numerical analysis aids in the choice of the most suitable method.

Scaling

Another aspect of analysis intimately associated with most digital computers is the matter of *scaling;* that is, ensuring that all numbers handled in the computer retain significance while fitting into words of fixed length. It is beyond our present scope to discuss the several established procedures for dealing with this sometimes troublesome problem; suffice it to mention that one of the techniques involves the use of a number representation called *floating point*, where the position of the decimal or binary point is specified by a special part of the number, like the characteristic of a logarithm. The G-15 has been designed to facilitate arithmetic with numbers of this form, not by inclusion of elaborate circuitry or expensive components, but through the operation of an unusually efficient programmed subroutine. This subroutine forms an integral part of the interpretive routine mentioned previously, with the result that scaling is among the difficulties avoided in programming.

Flow Chart

Once a problem has been properly stated, the numerical procedures established, and scaling settled, the actual writing of a detailed program is facilitated by the use of a flow chart (Fig. 5), showing the sequence of major steps and alternative branches dependent on conditions encountered as the computation progresses. The complexity of

X	1	X	3	LOC.	½	T	T_s	cb	S	D	½	NOTES
X	5	X	7	000	+	002	002	1	20	28	+	a = (20, 01) ± AR
8	9	10	11	002	+	004	004	1	20	29	+	b = (20, 03) ± AR+
12	13	14	15	004	+	006	006	1	28	07	+	c = (AR) ± 07, 05
16	17	18	19	006								
20	21	22	23									

Fig. 6. Three G-15 commands for the addition of two numbers and the storage of their sum. (1) The command in Loc. 000 causes the number *a* to be transferred (i.e., copied) from its storage location (line 20, word 01) to the accumulator register AR. The destination number 28 provides that *a* replaces the previous contents of AR. (2) The command in Loc. 002 transfers the number *b* from line 20, word 03, to AR. Here the use of destination number 29 causes an addition to *a*, the previous contents of AR. (3) Loc. 004 contains a command which stores c, the sum of *a* and *b*, in line 07, word 05. The next command would be placed in location 006. The time required to read and execute these three commands is about 1.6 milliseconds.

a problem determines how elaborate its flow diagram need be, not only to aid the programmer but also to serve as a map of the completed work. Sometimes the operations included in one block of a comprehensive diagram are displayed in more expanded detail on a separate flow chart.

With the flow diagram as a guide, the detailed steps of computer operation are planned in terms of individual commands. If two numbers are to be added, for example, three commands are usually required (Fig. 6). The first number is transferred to an accumulating register to replace its former contents; the second number is then transferred to the same register so as to add to the first; finally, the sum is transferred to storage, either to be used later in the computation or to be converted to the binary-coded decimal form for typeout.

It was mentioned earlier, and illustrated by the example of addition, that a G-15 command (in machine language, as contrasted to simplified coding) provides for the transfer of a word or more from one memory line to another; i.e., from a source to a destination. However, some operations, such as multiplication, division, initiation of input or output activities, and others, do not involve such a transfer per se; these operations are specified by commands in which a special code takes the place of a destination number and a source code indicates which operation is called for.

Optimizing the Access Time

After the total number of commands, including those in subroutines, has been determined, memory lines can be allocated for their storage as well as for numerical data. The location within its line of a command or number can be assigned as a program sheet is filled in with decimal command codes, so as to minimize the time of access during automatic operation. For the G-15, programs with minimum delay times are just as easy to write as less efficient ones. In most cases, there need be no pauses between reading a command, executing it, and reading the next command. With access optimized, the three commands in the addition example can be read from memory and executed in about 1.6 milliseconds.

Check-Out and Break Point

Whenever a new program is written, it can be expected not to work at the first trial because even the best programmer, being human, is inherently fallible. To detect his mistakes it is essential that a *test case* be prepared in order that intermediate, as well as final, results may be verified. Usually the sample will be much shorter than a typical productive computation, for a single pass through an iterative sequence of commands tests them as effectively as many repetitions. It is important, though, that *no condition or branch of the program be neglected during the check-out process.*

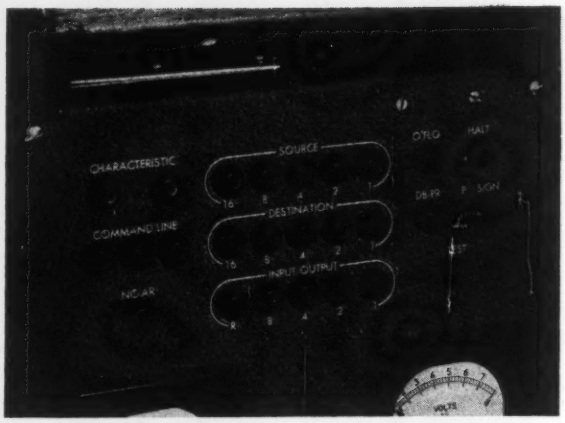


Fig. 7. Small panel of neon lights indicates the last command the computer has executed when computation stops after a halt command, a break point, or a single cycle operation.

Automatic operation of the G-15 can proceed in either of two modes, selectable by an external switch. In production runs, it will compute until a command to halt is reached; in checking a program, it can proceed through a sequence of commands at high speed until a programmed *break point* is recognized. Then the contents of any part of memory can be typed out for examination, after which computation may be resumed until the next break point or a command to halt appears. It is possible also to cause the G-15 to execute a single command at a time. When computation stops after a halt command, a break point, or a single cycle operation, the operator can read from a small panel of neon lights (Fig. 7) information about the last command the computer has executed.

To summarize the procedures for using an automatic digital computer, there are three principal activities: (1) problem statement and analysis, (2) program writing and debugging, (3) productive computation.

Examples of Application

There have been so many allusions, in both technical and popular journals of the past decade, to the spectacular achievements of million-dollar computers that you may wonder whether real capability and versatility can be found in a modest tool like the $45,000 G-15. Actually, the variety of applications to which it is suited is so large as to defy any attempt at completeness in a brief listing. To illustrate its usefulness, therefore, two examples have been chosen because they can be understood without profound knowledge of specialized technology or advanced mathematics. The first application, to highway construction, illustrates how the G-15 can save more than 90% of the time and cost otherwise required for calculations that must be performed dozens of times per mile of road.

Building a highway requires the movement of earth: low places must be filled; ground above roadbed level

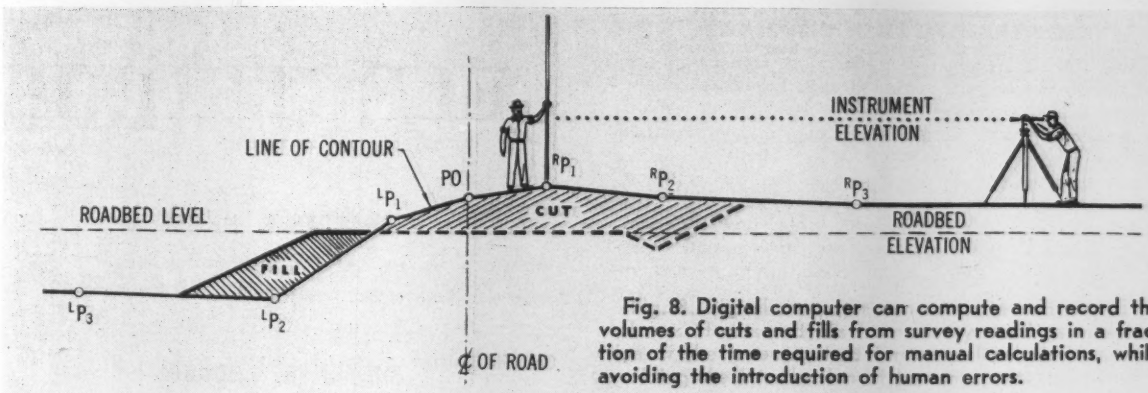


Fig. 8. Digital computer can compute and record the volumes of cuts and fills from survey readings in a fraction of the time required for manual calculations, while avoiding the introduction of human errors.

must be cut and removed. The cost of such work depends, of course, on the volumes of the cuts and fills, which can be calculated from survey readings. A typical calculation, which requires 30 to 45 minutes for each cross section when performed manually, can be accomplished with automatic type-out of results by the G-15 in about 15 seconds. Allowing an average of 1¼ minutes for the transcription of surveyor's field notes on the input typewriter, the G-15 shows an advantage in elapsed time of as much as 30 to 1.

In addition to quantities which change infrequently, such as the width of the road, the following data enter the calculations for each station: (1) survey rod readings and the distance of the readings from a base line, (2) station number, (3) height of the roadbed, (4) height of the instrument, (5) left and right side slope ratios, (6) depth of left and right ditches. From these data are calculated and recorded: (1) depth of cut or fill at left and right slope stakes, (2) horizontal distance of left and right slope stakes from the center line, (3) "cut" volume between preceding station and present station, (4) cumulative total of "cut" volumes, (5) "fill" volume between preceding station and present station, (6) cumulative total of "fill" volumes. (7) net difference between cut and fill. (8) cumulative difference between "cut" and "fill" volumes, adjusted to include a shrinkage factor. Included in the calculations are such operations as a determination of the point of intersection between the land contour and the road elevation, decisions whether each element of volume is a cut or a fill, etc.

Application of the Bendix G-15 to this and other problems associated with highway construction and traffic control will conserve public funds while expediting the creation and improvement of transportation facilities.

The automation of an industrial process serves as a second example of the practical use of the G-15. Here the computer is coordinated with other units in a system designed and produced by the Bendix Aviation Corporation for the automatic control of machine tools. Numerical data describing the contours and tolerances of a piece to be produced by a milling machine are tabulated from engineering drawings, together with information about the radius and feed rate of the cutting tool. These data, after being transcribed on a punched paper tape, are fed into the G-15 to enter calculations resulting in the specification of the path of the tool center, with components of motion in either two or three dimensions. Output from the G-15 consists of a second punched tape containing the calculated results arranged in the special form required by a machine-tool-control unit. This tape contains all the information necessary to direct the milling machine in high-precision automatic production.

Further examples, numerous and varied, could be cited to illustrate both present and future applications of the general-purpose digital computer in private industries and public agencies. The two cases above indicate, however, the increasingly important contributions of an automatic general-purpose computer of moderate size to the automation of processes involving the application of practical mathematics.

Song of Instruments—*Tale of a Defective Manometer Bank*

I sing a song of instruments:
(No sadder tale I know)—
Four and twenty silver tubes
Lined up in a row.
When their box was opened
The tubes and everything
Were horribly defective
And hardly worth a string!

But hands so mechanistic,
And dexterous, and strong,
And curses mixed with laughter
Combined to right the wrong.
And when those tubes were finished,
And set up on their feet,
'Twas thought their hundred inches
Perhaps would be complete.

But then, alas, 'twas not enough,
As later tests revealed:
So now the tubes are more complex
With higher pressures soaled.
Now four and twenty toggle valves
Have doubled all the tubes,
But now it looks as though the tests
Will triple them in cubes!

So sad my song of instruments
That once were twenty-four.
Today they number sixty-six:
Tomorrow maybe more!

Clifford B. Haughton, Jr.

ELECTRONIC

CHARLES F. KEZER
Key Electric Corp.

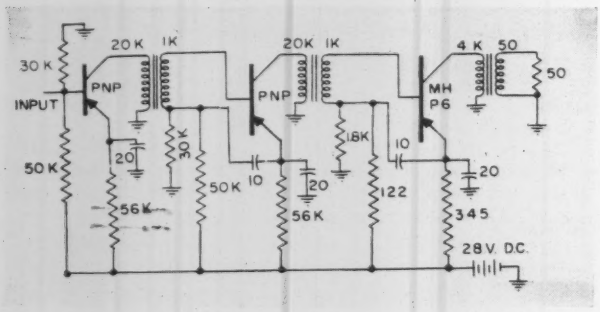
and

MILTON H. ARONSON
Instruments & Automation

TRANSISTOR SERVO-PREAMPLIFIER USES TRANSFORMER COUPLING

Three PNP alloy-junction germanium transistors provide 100-db power gain in this circuit. Intended to operate from a low-impedance control transformer or pickoff, the amplifier will drive a transistor, magnetic, or vacuum-tube power stage.

Each transistor stage is connected in the common-emitter configuration, analogous to the familiar grounded-cathode triode. Unlike vacuum tubes, however, transistors have low input resistance and high output resistance; hence the coupling transformers are connected for step-down. Impedance ratio is 20:1 for the interstage transformers and 80:1 for the output transformer.



First two stages consist of 50-milliwatt transistors (available from a number of manufacturers). These types have an α (current amplification factor) of about 0.97. In the third stage, a Minneapolis-Honeywell P6 two-watt type is used. Its α is 0.925.

Circuit was designed for servo carrier-frequency of 400 cps, but output is down only about 5 db at frequencies above 10 kc. Power gain drops at frequencies below 400 cps due to transformer characteristics.

Power gain is independent of temperature over the range of $-60°$ to $+55°$ C, decreasing for still higher temperatures. Decrease in power gain at elevated temperatures results from changes in transistor parameters, which in turn produce higher direct currents in the transformer windings, resulting in increased power losses in the transformers.

An R-C-coupled amplifier using the same transistor types is shown in the next circuit.

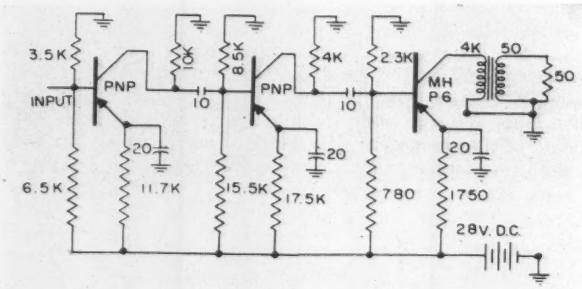
Power gain: 100 db at 400 cps.
Source resistance: 10 ohms.
Load resistance: 50 ohms.
Input resistance: 4000 ohms.
Temperature effect: Uniform power gain from $-60°$ C to $+55°$ C; down 8 db at 75° C.
Frequency response: 3 db down at 400 cps and 12 kc.
Phase shift at 400 cps: $-157°$.
Power supply: 28 v dc at 7 ma.
Source: A. N. DeSautels, Minneapolis-Honeywell Regulator Co., Minneapolis, Minn. Also AIEE Transactions Paper 56-37.

R-C-COUPLED TRANSISTOR AMPLIFIER

When R-C coupling replaces the interstage transformers of the preceding circuit, coupling losses due to mismatching reduce the over-all power gain to 84 db. At the same time, high temperature performance is improved, phase shift is reduced, and production cost is lowered.

Coupling capacitors are 10 uf; this high value (by vacuum-tube-amplifier standards) is required to keep the capacitive reactance low with respect to transistor input impedance in order to obtain satisfactory low-frequency response. If low-frequency operation were not required, smaller capacitors could be used for coupling and bypass. Tantalum electrolytic capacitors are used. These compact capacitors have excellent high-temperature characteristics, but capacitance decreases at lower temperatures, producing lowered gain and increased phase shift.

For applications in which lower power gain is adequate, the emitter bypass capacitors (20 uf) can be omitted, with minor design changes. The resulting degeneration (analogous to an unbypassed cathode resistor)



lowers gain, but improves stability and frequency response. This applies equally well to the transformer coupled circuit, and to the circuit to follow.

In the next circuit, direct-coupling is used with the same transistor types.

Power gain: 84 db at 400 cps.
Source resistance: 10 ohms.
Load resistance: 50 ohms.
Input resistance: 1800 ohms.
Temperature effect: Power gain is down 12 db at $-60°$ C, down 3 db at 80°C.
Frequency response: Down 5 db at 200 cps; at higher frequencies flat to above 20 kc.
Phase shift at 400 cps: $-64°$.
Power supply: 28 v dc at 18 ma (est.).
Source: A. N. DeSautels, Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.; also AIEE Transactions Paper 56-37.

DIRECT-COUPLED TRANSISTOR AMPLIFIER

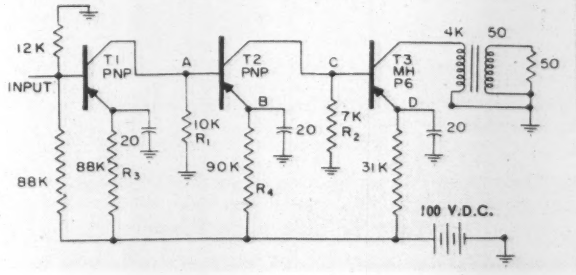
The direct-coupled transistor amplifier shown here has fewer components than the preceding circuit. It also provides good high-temperature performance, little phase shift, and substantial power gain (92 db). Its chief dis-

CIRCUITRY

The circuit is the heart of all electronics. Here are 4 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

advantage is the higher power-supply voltage (100 v dc) required. This higher voltage is needed to maintain practical values of collector-to-emitter d-c voltages.

In a direct-coupled transistor amplifier, the collector-to-ground direct voltage of one stage is the base-bias voltage of the following stage, and is approximately equal to the emitter voltage of that stage. It is desirable for good bias stabilization for the series emitter resistors (R_3 and R_4) to be about 10 times the corresponding collector



circuit resistances. With a 28 v d-c supply, only about 2.5 v d-c would thus be available to be dropped across T_2 and R_2, which is impractical.

Interchanging ten transistors of three different makes in the first two stages (of all three amplifiers) produced a spread in over-all power gain of only 10%. Feedback networks could be used to decrease this spread at the expense of power gain.

Power gain: 92 db.

Source resistance: 10 ohms.

Load resistance: 50 ohms.

Input resistance: 1600 ohms.

Temperature effect: Power gain drops to 85 db at −60° C and to 87 db at 80° C.

Frequency response: Down 3 db at 200 cps and 20 kc.

Phase shift at 400 cps: −78°.

Power supply: 100 v dc at 6 ma.

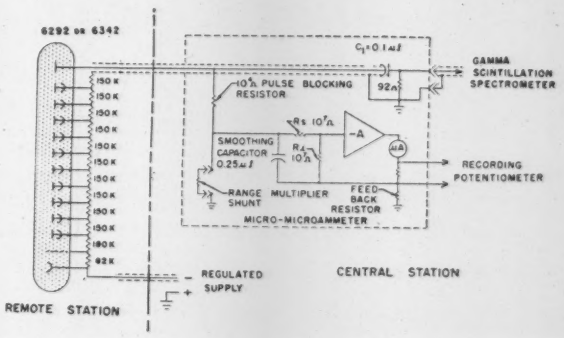
Source: A. N. DeSautels, Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.; also AIEE Transactions Paper 56-37.

GAMMA MONITOR IDENTIFIES AND EVALUATES ACTIVITY

This dual-function gamma monitor identifies and evaluates gamma emitters (such as spent nuclear fuel) over a wide range of gamma activity. It uses both the a-c and d-c component of the signal developed by a multiplier phototube sighted on a thallium-activated sodium-iodide crystal.

The d-c output from the detector (plus others located adjacent to sample-holders) is recorded as the gross gamma activity. The pulse output is scanned in conventional manner by a scintillation spectrometer to identify the gamma-emitting isotope.

The gamma detector is designed around the 2-inch DuMont 6292 or 6342 multiplier phototube. The phototube high voltage is adjusted until the 0.663 mev total absorption peak of a Ca-Ba-137 calibration source is of the desired amplitude. The RG26/U pulse cable is terminated in its 92-ohm characteristic impedance so that cable lengths of 50-250 ft will have negligible effect on pulse amplitude. Coupling capacitor C1 must have high shunt resistance in order not to shunt the high impedance of the micro-microammeter input, and low series resistance so as not to affect the 92-ohm cable termination. Cornell-Dubilier Type CUB was used.



It was found that from 1000 to 1400 volts were required to produce a photomultiplier gain (ratio of charge per pulse received at anode to charge per pulse received at first dynode) of 300,000. Average voltage used was 1127 volts. At gain of 300,000, average background dark current of tube was 1.3×10^{-8} ampere; equivalent to a solution concentration of about 10 uc/liter (the low-level limit of system).

Maximum linear range of detector is limited by maximum recommended anode current of 100 ua, equivalent to solution concentration of 100 mc/liter.

Accessory instruments: (1) Micro-microammeter is vibrating-capacitor-type Beckman Instrument Company, Model V, operated with a 10-megohm input resistor. The shunt circuit shown increases the current range; resistor R_S (10^7 ohms) equal to the input resistance of the micro-microammeter is used in series with the input so that the higher value input currents do not disturb the feedback circuit because they pass through the shunt to ground. (2) Gamma spectrometer amplifiers: Oak Ridge A1A preamplifier and AID amplifier operated at bandwidth of 0.5 Mc; plus Francis single-channel differential analyzer driving a 4-cycle count rate meter of the log diode type. (3) Recording potentiometer: Foxboro recorder with sensitivity of 50 mv.

Gross Gamma Range: 10 microcuries per liter to 100 millicuries per liter (range of 10^4).

Spectrometer range: 10 microcuries per liter to 1 millicurie per liter (range of 10^2).

Multiplier Phototube High Voltage Supply: 1127 volts average at 640 ua.

Source: R. E. Connally, General Electric Company, Hanford Atomic Products Operation, Richland, Washington, also *IRE-PGNS*, Vol. NS-3, No. 2, March, 1956.

Control Valves -- No. 9

Positioners for Diaphragm Actuators

Valves must be positioned accurately to function as precise control elements. Valve positioners are control devices designed to impart sensitivity to the valve and to insure accurate positioning as dictated by the control signal.

C. S. BEARD
Foster Engineering Company

CONTROL VALVES have inherent operating characteristics which make difficult their precise positioning under varying operating conditions. Consider the movement of the main valve (plug) of a diaphragm-operated valve designed to operate on 3-to-15-psig air-signal output from a control instrument. This valve is required by numerous specifications to be within 3% of half-open position with 9-psig pressure on the diaphragm *when there is no pressure differential across the valve seat or no line pressure on the packing.* Obviously, any pressure differential across the valve or any line pressure on the packing, as occurs in service, creates additional force that tends to open or close the valve or otherwise prevent it from assuming the position called for by the controller.

Nevertheless, precise positioning of the inner valve—independent of these varying operational factors—is necessary if the accuracy of the control system is to be comparable to the accuracy of the controller with which the valve is used. Modern controllers are accurate and sensitive; their output pressure varies with minute change of the measured variable. Comparable precision in positioning the valve operated by the instrument is necessary, particularly under some conditions which will be discussed in detail. Where such precise valve positioning is required, an auxiliary device called a *valve positioner* is used to increase or decrease the air pressure operating the actuator until the valve stem reaches the position called for by the instrument controller.

When To Use a Positioner

Although numerous process systems can benefit from use or installation of a valve positioner, the precise point at which the positioner becomes necessary is difficult to set. The following are the most important conditions where use of a valve positioner is indicated.

1. High Pressure-drop Across Valve

The pressure drop across the valve is a force that tends to reduce the accuracy of positioning of the valve. Increase in this pressure drop tends to decrease the stability of any valve, single seated or balanced. Although the effect is much smaller in the balanced valve than in the single-seated valve, there are conditions under which the ratio of diaphragm force to spring load of even a balanced valve is not sufficient to position the valve to an acceptable accuracy. This is particularly true if the unbalanced force reverses direction during the valve stroke.

The effect of pressure drop on the single-seated valve often limits the usefulness of this type of valve. Hence the valve positioner makes possible much greater application of the single-seated valve, which has the added features of tight shut-off and adaptability to Venturi design.

The particular pressure drop at which various companies recommend the use of a valve positioner with either single- or double-seated valves varies widely—

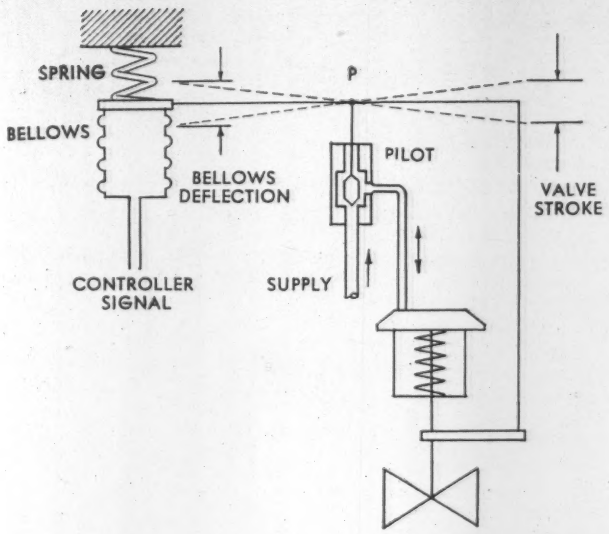


Fig. 9-1. Basic position-balance (or deflection-balance) system comprises bellows, beam, and pilot valve. Bellows receives controller signal and moves pilot, which changes loading to diaphragm actuator so that valve stem moves an amount proportional to the controller signal. At this point the pilot is returned to its equilibrium point P (within a small fraction of an inch).

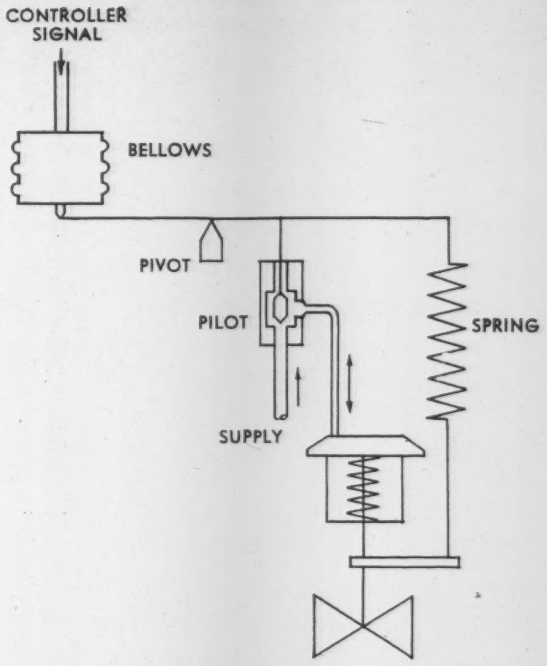


Fig. 9-2. Basic force-balance system has beam that is balanced between one force (produced by bellows receiving the controller signal) and an opposing force (produced by a spring attached to valve stem). An unbalance causes pilot to change diaphragm loading signal to move stem and restore a balance of forces.

from as low as 60 psi to as high as 250 psi, depending on the size of valve, the positioning accuracy required, etc.

2. Control with Wide Throttling Range

Many processes require accurate control of the variable over a wide range. For example, when the feed to a still is being drawn from an accumulator it may be required that the entire volume of the accumulator be used—that is, the level in the accumulator will vary from empty to full, and the discharge valve must control the flow over the entire wide range of level. Full throttling range of 100% (full to empty) must be used; yet the discharge valve must react correctly to even small changes in level at any point.

A wide throttling range means reduced accuracy and sensitivity at any one point because the output of the instrument changes less per unit change in variable when the throttling band is widened. Hence precise positioning with a wide throttling band indicates use of a valve positioner.

Large Characterized-port Valves

Many valves in process control have ports machined to obtain a particular characteristic curve. A constant relationship between the output of the controller and the stem position of the control valve is necessary to take full advantage of the characteristic. In most cases a valve positioner is indicated when the valve size is 4″ or larger.

4. High-pressure Applications with Tight Packing

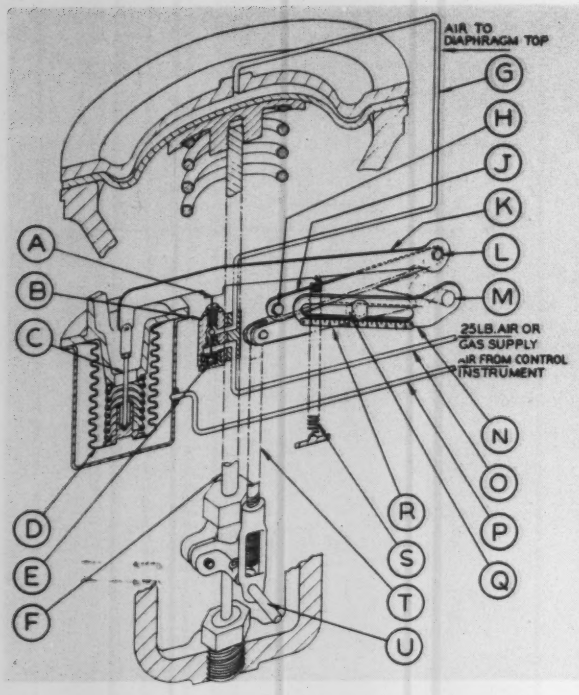
Stems that stick require a valve positioner. Holding high pressure with most forms of packing is difficult without occasionally causing the stem to stick. Such sticking is due not as much to the type of packing available as to the effects of slight misalignment in valves which require close tolerances in guiding. Valves have been discussed that incorporate design features to eliminate packing. However, their application has been confined mostly to other than high-pressure installations.

5. Valves Handling Sludge or Solids in Suspension

Valve positioners are required when materials are handled that cause sticky stems or guides, or when lumpy material flows through ports.

6. Non-standard Pressure Requirements of Operator or Non-standard Output from Controller

One of the few conditions in process work that have been standardized by most instrument suppliers is the 3-to-15-psig range of pneumatic output from the controller. Most valves are designed with diaphragms and springs to give full operation when pressures in this range are delivered to the diaphragm. However, many actuators, such as cylinder types, operate on pressures higher than the accepted 15 psig. The valve positioner can be used as a proportional relay or amplifier, accepting the 3-15-psig controller output and delivering a signal of any desired range to the valve actuator, such as 6-60 psig.



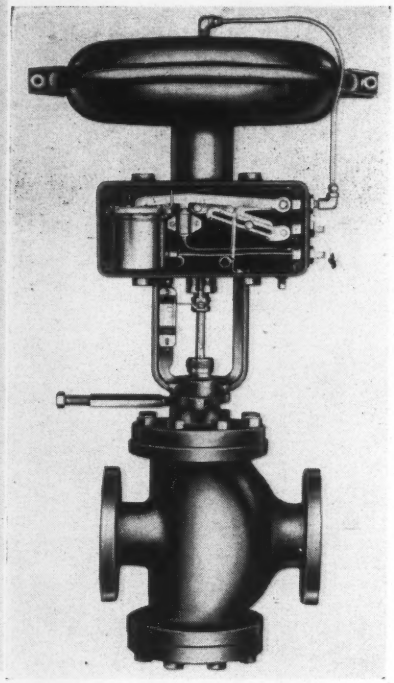


Fig. 9-3. Bristol positioner is position-balance type. Beam K is positioned by signal-receiving bellows (D) at one end and by valve-stem-position linkage at other end. Any change in bellows signal causes pilot (B) to change loading pressure on diaphragm so that valve stem moves a proportional amount. Linkage permits adjustment of sensitivity.

7. Split-range Operation

It often is required that a portion of the standard 3-to-15-psig signal from the instrument controller be used to cause full travel of a valve requiring full 3-to-15-psig signal for its operation. Examples are in sequential operation of 2 or 3 valves by a single instrument—one operating on, say, the 3-to-7-psig portion of the instrument output range, the next on 7-to-11-psig, and a third on 11-to-15-psig. Most valve positioners can be either adjusted or modified (by simple spring replacement) to produce this "split-range" operation. A valve positioner on the first valve would be adjusted to give 3-to-15-psig output with 3-to-7-psig input; a valve positioner on the second valve would be adjusted to give 3-to-15-psig output on 7-to-11-psig input; a valve positioner on the third valve would give 3-to-15-psig output on 11-to-15-psig input.

Innumerable operations use this feature, including the heating of exchangers with exhaust steam, use of high-pressure make-up steam to augment low-pressure steam, etc.

8. Reverse Valve Operation

Valve positioners can be used also to obtain reverse valve action—that is, the positioner delivers a decreasing output to the valve diaphragm with increasing signal output from the controller. Most controllers are built with a reversible output feature, but many systems include some valves which move from closed to open position and others which move from open to closed position. One controller can be used with several valve-positioner-equipped valves to accomplish this function.

9. Increased Speed of Operation

The small volume of the operating bellows of a valve positioner reflects a change of controller output pressure much more rapidly than the larger volume of a diaphragm or piston operator. Particularly when using higher pressures with a springless operator, valve operation time can be cut by as much as 80% by use of a valve positioner. In addition, the valve can be operated at a much greater distance from the controller.

10. Positioning Cylinder or Springless Actuator

In the discussion of springless actuators (Chapter 6) it was brought out that a position of the valve stem cannot be determined as easily as when a spring is used to oppose the controller output. Stem position must be sensed to control the air pressures required on *each* side of the piston or diaphragm in order to obtain the desired position. A valve positioner can perform this function.

Basic Positioner Designs

Many valve positioners are available commercially. Most differ only in design details; the principles are essentially similar. The positioner is mechanically connected to the stem of the valve, and this stem position is compared with position called for by the instrument controller (that is, the instrument output air signal). A separate air supply is brought into the positioner for positioning the valve at exactly the point called for by the controller.

Two approaches to the design of positioners have been taken by manufacturers—(1) deflection (or position) balance and (2) force balance.

Position (Deflection) Balance

The basic position-balance system is shown in Fig. 9-1. The basic elements are (1) a bellows that receives the instrument signal, (2) a beam that is fixed to the bellows at one end and to the valve stem at the other (through linkage), and (3) a pilot valve that is connected to the beam at a point P. There is no fixed pivot point. Whenever the bellows moves in response to an in-

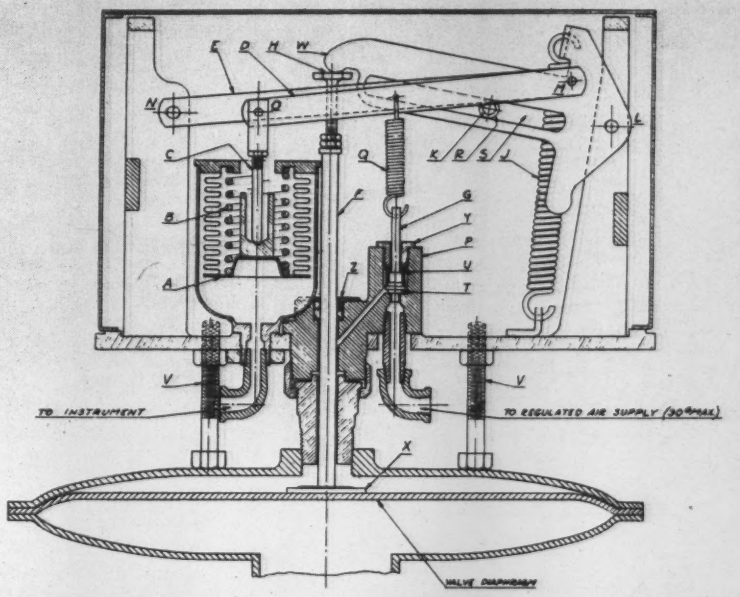


Fig. 9-4. Minneapolis-Honeywell, Industrial Div., positioner is position-balance type. Bellows at left receives instrument signal and moves beam D. This moves pilot T which changes diaphragm loading. Valve stem motion repositions pilot via feedback rod (F) and levers that permit adjustment of sensitivity.

strument signal, the pilot is moved and either admits air to or bleeds it from the diaphragm until the valve stem position corresponds to the instrument air signal. At this time the pilot is again at its neutral or equilibrium position.

As shown in Fig. 9-1, there is one valve position for every corresponding bellows position when the pilot is at equilibrium. Although point P moves when the valve is not in equilibrium, it returns to the point shown (within a few hundredths or thousandths of an inch) when the valve is at equilibrium. It is essentially a floating pivot point. This action causes the motion of the valve end of the beam to be exactly proportional to the motion of the bellows end of the beam.

Force Balance

The second basic design approach uses the *pneumatic force-balance principle*, shown in Fig. 9-2. In addition to the same 3 basic elements of the position-balance system (bellows, beam, and pilot) the force-balance system includes a *fixed pivot point and a spring that produces a force proportional to the valve stem position.* In this system the pilot is at equilibrium whenever the force produced by the bellows is balanced by the force produced by the spring; hence the name "force balance." For every force produced by the bellows there is one corresponding force produced by the spring that returns the pilot to equilibrium. Whenever this condition does not prevail, the pilot either admits air to or bleeds it from the diaphragm until the pilot returns to equilibrium.

The bellows force can be balanced either by spring (as shown in Fig. 9-2) or by diaphragm elements, as will be described.

Position-Balance-Type Positioners

The Bristol Company

The positioner shown in Fig. 9-3 is a typical position-balance-type positioner. The beam (K) is attached at one end to the bellows (D) receiving the controller signal, and is attached to the valve stem at its other end by a system of levers. The pilot (B) is also attached to the beam. Hence this positioner operates exactly like that described in Fig. 9-1. The system of levers is used to permit adjustment of the sensitivity (proportional band) of the positioner; the position of pin Q in arm R determines the amount of feedback motion transmitted from the valve stem to the beam K. As described for Fig. 9-1, there is one position of the controlled valve stem for each corresponding value of air pressure signal from the instrument controller.

Minneapolis-Honeywell, Industrial Div.

Fig. 9-4 shows another position-balance-type positioner. Here again the basic elements are the spring-loaded bellows (A), the beam (E), and the pilot valve (G-U-T). Valve position is fed back to the beam via rod F and levers. The system of levers makes it possible to adjust the sensitivity (proportional band) via a change in position of pin K in slot S.

Change in instrument signal to the bellows causes motion of the pilot valve, which either admits air to or bleeds it from the diaphragm; resulting valve stem motion repositions the pilot valve, which returns to equilibrium position when the valve has assumed a position corresponding to that called for by the instrument signal.

The Foxboro Company

The positioner shown in Fig. 9-5 (Type B Vernier Valvactor) is another position-balance positioner. The beam (A) is attached to the valve stem at one end (through wheel D and a linkage) and to the instrument-signal bellows (H) at the other end. The wheel D is used to adjust the sensitivity of the unit, and the beam is calibrated for this purpose. The system also has the third basic element shown in Fig. 9-1, a pilot relay valve (P).

However, this system has one refinement not shown in Fig. 9-1—the flapper-nozzle unit by which the pilot is made to follow the motion of the beam. Whereas the pilot is fixed mechanically to the beam in Fig. 9-1, the pilot in

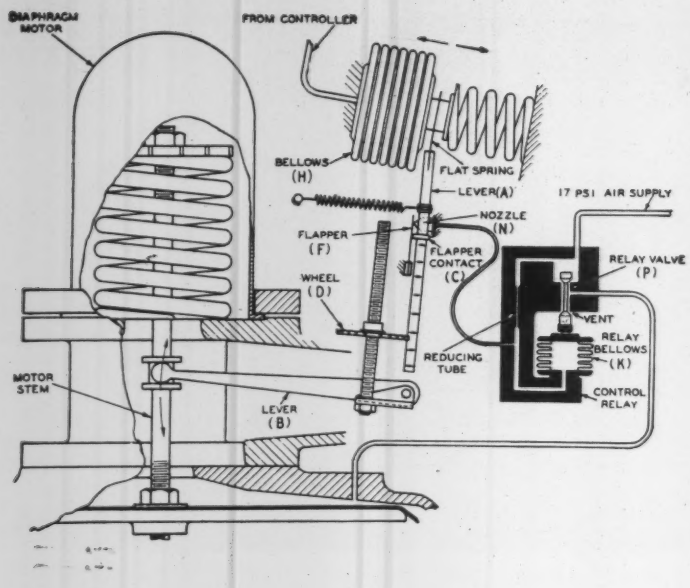


Fig. 9-5. Foxboro "Vernier Valvactor" is position-balance type, with flapper-nozzle unit that causes pilot P to follow motion of beam A precisely.

Fig. 9-5 is made to follow the beam motion precisely via the flapper-nozzle unit.

The way in which this is done is as follows: Suppose the controller signal increases in pressure. The bellows H expands and moves the upper end of the beam clockwise about the point where wheel D meets the beam. The beam moves away from the spring-loaded flapper, allowing it to cover nozzle N (which is attached to instrument case). This increases the pressure in bellows K, which moves the pilot valve to admit higher pressure to the valve diaphragm. This in turn causes stem motion which moves the lower end of the beam in such a manner as to *return* the flapper to its original position with respect to the nozzle. When the stem has moved to its proper position, the flapper has returned exactly to its original position. Hence the flapper-nozzle system is essentially a relay which makes the pilot P follow the beam motion precisely; it is used commonly in pneumatic systems for this purpose (proportional position follow-up).

Taylor Instrument Companies

The positioner shown in Fig. 9-6 is another position-balance type that uses a flapper-nozzle arrangement to position a pilot valve. As in the other positioners, it contains a bellows that receives the instrument signal (1), a beam attached to the bellows at one end and attached to the valve stem via rod 11, a pilot (2) that controls the air loading to the diaphragm of the valve being controlled, and a flapper-nozzle unit (3 and 4) that causes the pilot to follow beam motion precisely.

Force-balance Positioners

The positioners described thus far have all been position-balance (deflection-balance) types in which the *position* of the valve stem was compared against the *position* of a bellows receiving the instrument signal, and which used a pilot valve to assure that the latter corresponds with the former.

The force-balance-type of positioner is similar to the deflection type except that the pilot is balanced between the *force* exerted by the signal-receiving bellows and a *force* exerted by a spring or diaphragm attached to the valve stem. The following are examples.

Fisher Governor Company

The positioner shown in Fig. 9-7 is a typical force-balance type. The pilot valve is balanced between two forces—one exerted by the instrument signal acting upon a bellows; the other exerted by the "force balance spring" attached to the valve stem via linkage.

The bellows assembly comprises two bellows, connected by push rods, which operate a double-action plug that controls supply and bleed ports. Note also that supply air to the positioner (25 to 250 psig) is filtered and regulated.

The action of the force-balance positioner is similar to that of the position-balance type. For every instrument signal there is only one valve stem position in which the force exerted by the force-balance spring is balanced by the force exerted by the bellows in the pilot. When this occurs the pilot is very near its equilibrium position (within a few thousandths of an inch) and the diaphragm pressure will be the value that is required to make the stem assume the desired position. If the stem is not at the position called for by the instrument signal, the pilot is unbalanced, and opens either the supply or bleed port to assure that the diaphragm signal drives the stem to the desired position. The adjustable linkage between the stem and the force-balance spring permits adjustment of the sensitivity.

Mason-Neilan Div.

Fig. 9-8 is another positioner of the force-balance type. The pilot is attached to a beam (marked "bellcrank lever") whose position is determined by two forces—one exerted by the bellows and the other exerted by the force-balance spring. (This spring is attached to the valve stem via linkage that permits adjustment of the sensitivity.) Note that the two forces are exerted in opposition—one tends to open the pilot and the other to close it; hence there is only one valve stem position for every bellows (instrument signal) position, and the pilot will either open or close to assure that this equilibrium position, where the two forces are in balance, is attained.

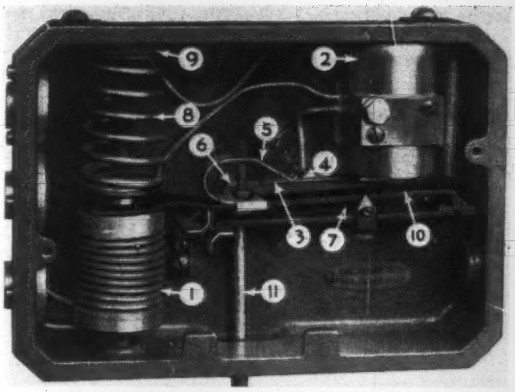


Fig. 9-6. Taylor positioner, a position-balance type, also has flapper-nozzle unit (3-4) to insure that pilot (2) follows beam motion (10). Beam is attached to signal-receiving bellows (1) at left.

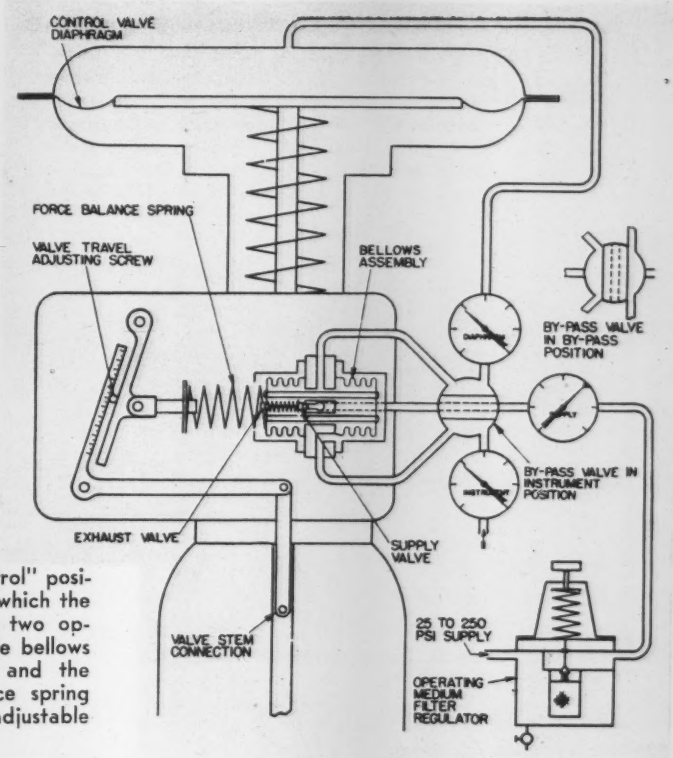


Fig. 9-7. Fisher-Governor "Positrol" positioner is a force-balance type in which the pilot valve is balanced between two opposing forces—one exerted by the bellows receiving the instrument signal and the other exerted by a force-balance spring attached to the valve stem via adjustable linkage.

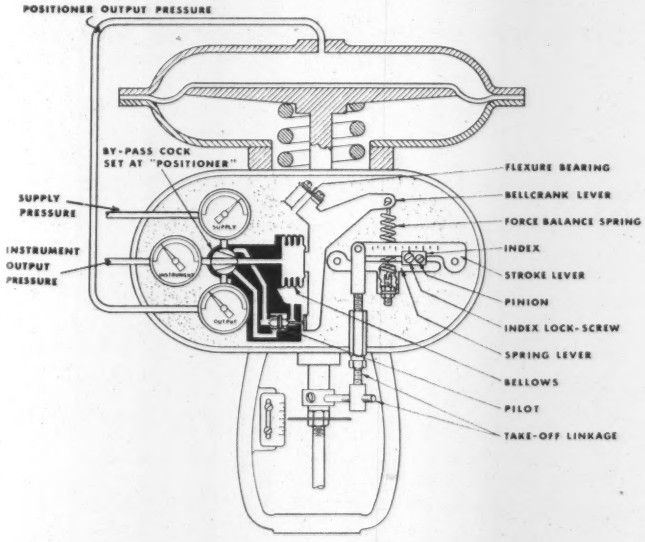


Fig. 9-8. Mason-Neilan positioner is of force-balance type also. Pilot is balanced between the two opposing forces—one developed by the bellows and the other by the force-balance spring.

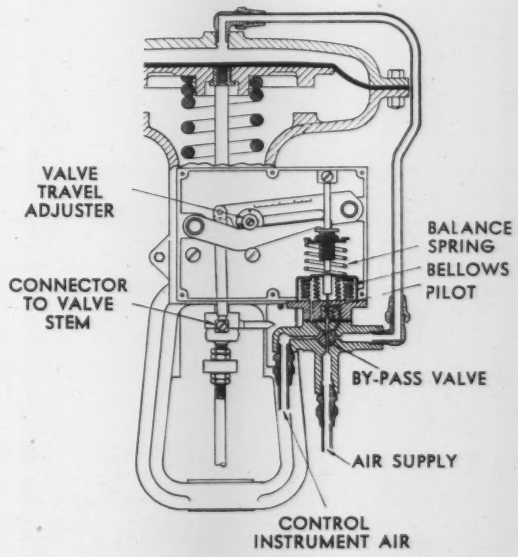
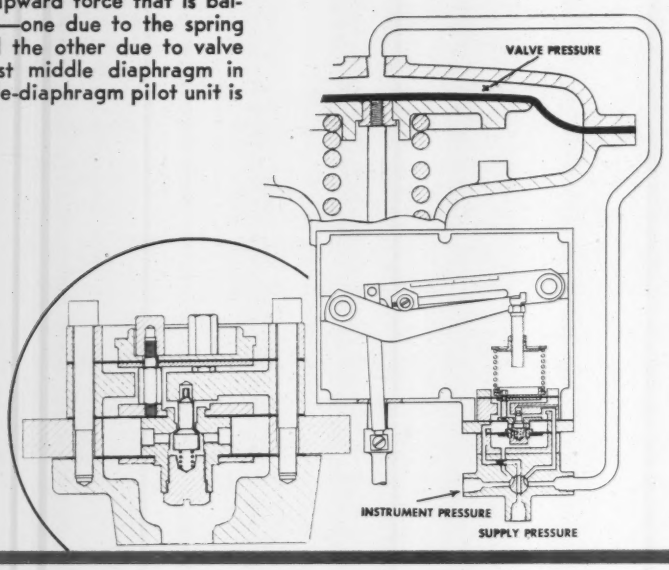


Fig. 9-9. This Moore Products positioner is force-balance type. Pilot is balanced between the opposing forces of the bellows and balance spring.

Fig. 9-10. This Moore Products positioner is a force-balance type that uses a triple-diaphragm unit (rather than a bellows) to develop the upward force that is balanced by two downward forces—one due to the spring attached to the valve stem and the other due to valve loading pressure exerted against middle diaphragm in pilot unit. A close-up of the triple-diaphragm pilot unit is shown at left.



Moore Products Company

This company offers several different types of force-balance positioners. In the one shown in Fig. 9-9 a bellows is used to balance the force of a balance spring that is attached to the valve stem. As shown clearly in the illustration, an upward force is exerted by the bellows, depending on the instrument signal; a downward force is exerted by the force-balance spring, depending on the stem position. When the two forces are in balance, the pilot is in equilibrium condition; when the two forces are not in balance, the pilot either opens or closes to change the pressure to the control valve diaphragm. This unit is similar in principle to the ones described previously (Fig. 9-2, 9-7, and 9-8).

However, the positioner shown in Fig. 9-10, which is also a force-balance positioner, uses diaphragms rather than a bellows to produce some of the forces. In this unit, three diaphragms are used in the pilot unit. The instrument signal exerts an upward force against the lower diaphragm, which has constant supply pressure exerted downwards against its upper face. Thus, increase in instrument pressure moves the seat of the pilot valve upwards, and permits the supply pressure to force air into the actuator diaphragm area. This does two things —the increased valve pressure acts downward on both the control valve diaphragm and on the middle diaphragm of the pilot unit. Both of these forces are balancing forces, tending to rebalance the pilot. In addition, a force exerted by the force-balance spring (attached to the valve stem) also exerts a downward balancing force—but this time against the upper diaphragm in the pilot unit. Hence the net result is that the *upward force* due to the instrument signal is balanced by the *downward forces* due both to stem position (spring) and valve pressure. This is said to increase the stability and capacity of the positioner, and to reduce air consumption.

A third type of positioner offered by Moore Products is shown in Fig. 9-11. Here again a three-diaphragm pilot unit uses the force-balance principle in which instrument air pressure exerts an upward force on the larger (center) diaphragm of the positioner because of difference in diaphragm areas. This upward force, plus the upward force of the range spring, is balanced by the downward force of the suppression spring, which is responsive to stem motion.

Next month: Although the positioners described thus far have their primary use with diaphragm actuators, they can be adapted to cylinder operation, as will be described next month in chapter 10—"Positioners for Cylinder Actuators," which include the Annin, Conoflow, Bailey, Foster, Foxboro, Hagan, and Republic Positioners.

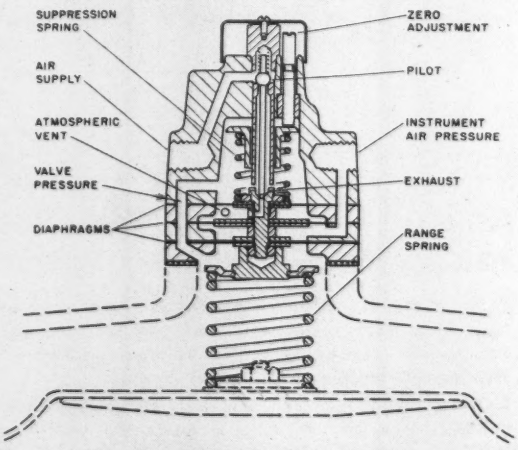


Fig. 9-11. "Built-in-type" positioner of Moore Products is force-balance type that uses triple-diaphragm pilot unit.

Fig. 1. Flight table with test load.

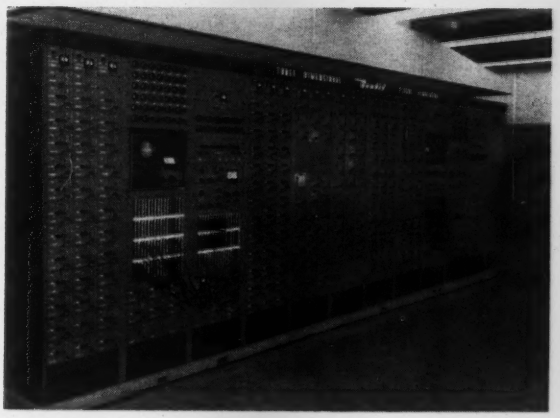


Fig. 2. Electronics unit simulates missile kinematics and commands the flight-table servo drives.

Flight-Table Instrumentation

A flight table permits actual equipment to be subjected to desired roll, pitch or yaw. Instrumentation includes position and velocity monitors for the three axis (roll, pitch and yaw) of the servo-controlled gimbals system. Transformation between earth and (simulated) aircraft coordinate systems is performed by vector resolution using four resolvers driven by each axis. Approximately 15 persons worked two years designing this flight-table structure, its servo drives and its instrumentation.

ROBERT H. ESLING
Bendix Aviation Corp.

BENDIX Three-Dimensional Flight Table (Fig. 1) consists of a high performance, servo-controlled gimbals system which follows command inputs from an analog computer. Missile sections and components mounted upon these gimbals are subjected to the torques, angular accelerations, and angular velocities which would be experienced in the flight being simulated. Instruments mounted on the gimbals system monitor position and velocity, and compute Euler-angle transformations. These are fed back to the analog computer. Outputs from equipment mounted on the gimbals system can be monitored or can be fed back to the analog computer for the purpose of closing a computing loop which utilizes the actual equipment-performance data rather than the simulation of this performance.

The electronics unit shown in Fig. 2 contains computational elements required for representing high-speed missile kinematics on a one-to-one time scale. This equipment commands the flight-table servo drives. Sufficient computing capacity has been included in the electronics unit to permit component testing and limited stability studies. The electronics unit contains 78 d-c amplifiers, 10 of which can be used as integrator amplifiers. It contains 5 electronic multipliers, with slaves, performing as many as 14 multiplications. Forty-eight potentiometers are available for scaling and for setting initial conditions.

Loaded with a 50-lb section of missile components the roll axis of the gimbals system has a natural frequency in excess of 100 cps. The yaw and pitch axes have natural frequencies in the region of 50 cps. Peak accelerations for the loaded system are: 2500 rad/sec^2 in roll and 500 rad/sec^2 in yaw and pitch. Peak velocities are: 50 rad/sec in roll and 15 rad/sec in yaw and pitch.

Instrumentation Needs for the Flight Table

Instrumentation needs for the flight table lie in three areas: the servo loops, the computing loop, and service systems. The servo loops are illustrated by the block diagrams of Figs. 3 and 4. In the servo loop forward path the primary instrumentation need is for a transducer to convert from d-c servo amplifier output command signal to a valve pilot stage position. In the various feedback paths of the multiloop servo system, transducers are needed for the feedback of gimbal velocity, gimbal position, valve spool position, and torque motor velocity. Transformations between earth and aircraft coordinate systems* must be accomplished by instruments in the computing loop, illustrated by Fig. 5, while calibration and position-limit sensing must be provided for by instruments in the service systems.

*See Simulation Council Newsletter account of Midwestern s/c meeting of 9 July on "Coordinate Transformation," page 1795.

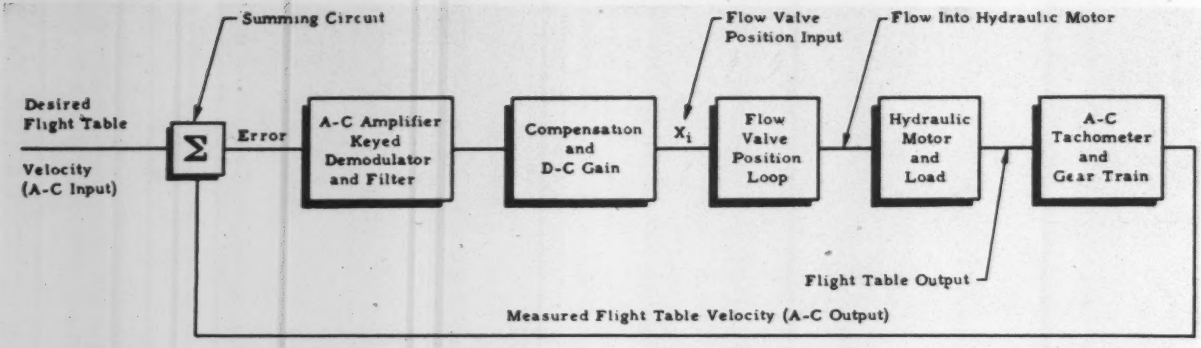


Fig. 3. Outer servo system for one axis. Hydraulic motor drives the desired gimbal at the required velocity. Difference between measured velocity and desired velocity is error signal for control of valve controlling the hydraulic motor.

Means of Instrumentation

Fig. 6 shows an exploded view of the servo valve, illustrating the torque motor used as a transducer in the servo forward path as well as the linear variable differential-transformer (Linearsyn) and the velocity transducer used in the valve loop feedback paths. The lag commonly found in torque motors (due to eddy currents in torque-motor pole pieces) has been eliminated in this torque-motor design. The undamped natural frequency of the torque motor and valve pilot stage is 500 cps. Elimination of the eddy-current lag produced a high resonant peak in the torque-motor frequency response at 500 cps. Therefore, velocity feedback was added around the torque motor to increase the effective damping of this instrument. The transducer which was used to accomplish this velocity feedback consists of a tiny permanent magnet moving within a coil. An output of approximately 100 millivolts is obtained in this velocity feedback transducer when the torque-motor armature oscillates at its natural frequency with an amplitude of $\pm 0.005''$.

As the power spool in the two-stage servo valve has no restraint, a position loop is needed around this stage of the valve to produce a power-spool position corresponding to a command input signal to the valve servo loop. Position sensing for the power stage spool is accomplished by the use of a linear variable differential-transformer. The core of this transformer is rigidly attached to the power stage spool and moves within the fluid region. The coils of the transformer are mounted at one side of the valve body and are shielded from the fluid region. Precise adjustment of power stage spool position for null flow is accomplished by micrometer-like positioning of the transformer coils.

Feedback for the gimbal velocity servo loop is provided by means of an a-c tachometer driven directly from the hydraulic servomotor shaft. Fig. 7 shows the mounting of these tachometers on the gimbals system. This tachometer is of the drag-cup type and is excited by a 1000-cps input.

Five resolvers are driven at a one-to-one ratio by each axis of the flight-table gimbals system. One of the resolvers in each instrument group is used for gimbal position indication. A position loop may be closed about any of the flight table axes using the appropriate resolvers as feedback transducers. Fig. 8 illustrates the instrument group associated with the yaw axis of the flight-table gimbals system. The remaining four resolvers on each axis are available as computing instruments. The block

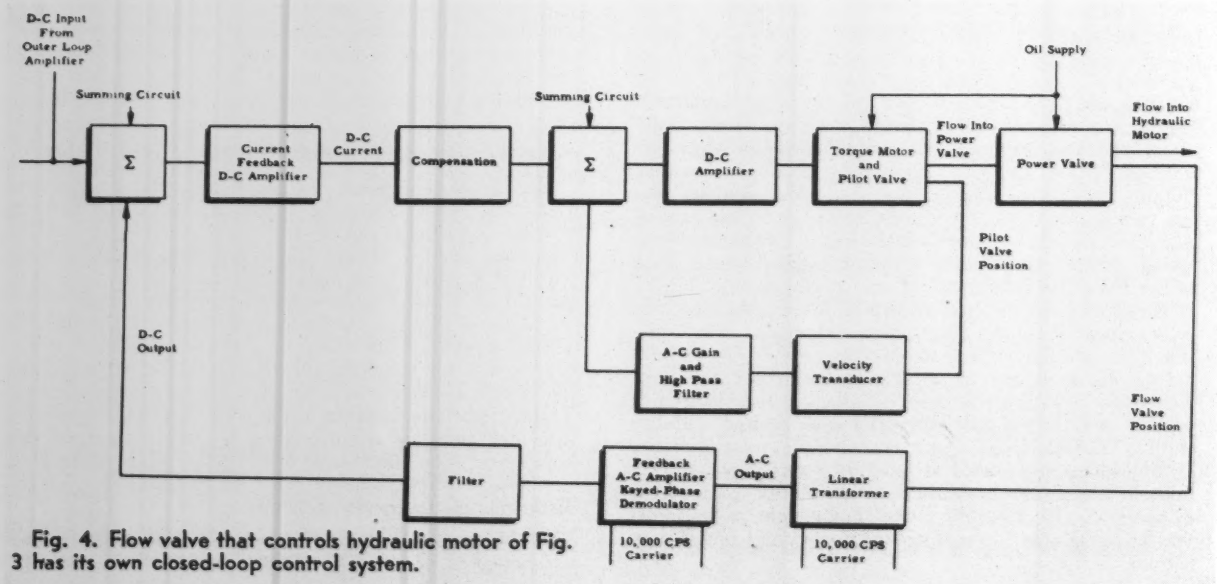


Fig. 4. Flow valve that controls hydraulic motor of Fig. 3 has its own closed-loop control system.

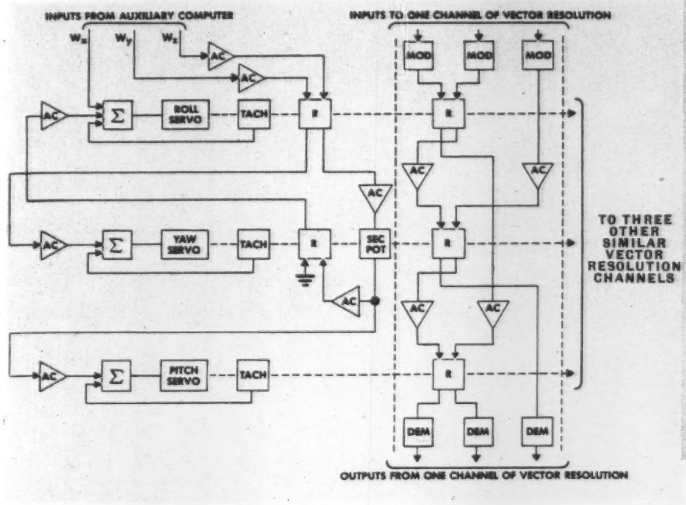


Fig. 5. Computing and vector-resolution system transforms between earth and aircraft coordinate systems by use of Euler-angle technique. Four vector-resolution channels similar to the one shown are available for simultaneous resolution of four vectors in a given problem.

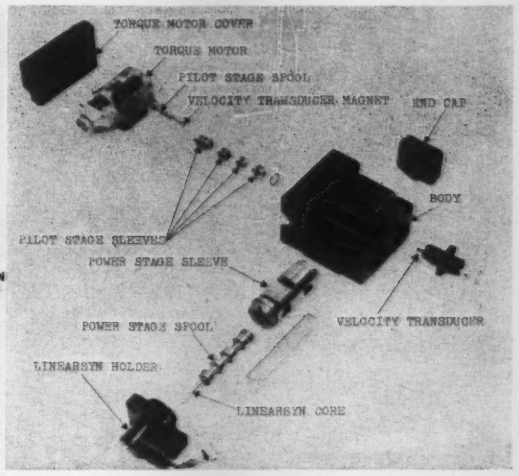


Fig. 6. Servo valve.

diagram of Fig. 5 shows how these resolvers are used to accomplish the transformation from missile coordinate system to earth coordinate system. In addition to these resolvers the yaw-axis instrument group contains a secant potentiometer which is also used in these computations.

Calibration and Test

For calibration and general test purposes a linear potentiometer is included in the instrument group associated with each axis of the flight table. Electrical slip rings and rotary hydraulic joints in the flight-table trunnions permit continuous rotation about each axis providing the load does not interfere with any of the gimbals. Rate calibration is therefore simply accomplished by recording the slope of the linear potentiometer output. When continuous rotation is not possible a motor revolution counter incorporated in each axis of the flight table permits calibration of the gimbals. This motor revolution counter is a variable-reluctance instrument which produces an output blip whenever a high permeability finger sweeps across the projecting ends of the coil cores. By synchronizing this blip with the output from a 25-cps oscillator incorporated in the electronics unit for the flight table an accurate measure of gimbal angular velocity is obtained.

To protect projecting loads and prevent interference between these loads and the flight-table gimbals, fail-safe position-limit sensing must be provided. This was accomplished by a cam-and-microswitch system used on the yaw and pitch axes. As a test load goes "out of bounds" the cam will first open a microswitch which signals the servo to either stop the rotating system at the "out of bounds" position or to return the yaw gimbal and load to zero position. It may be, however, that the reason for going out of bounds is loss of servo control. In this case the first position sensing will be ineffective and the system will continue to rotate until the cam opens a second microswitch. This second microswitch deenergizes a pair of rapid solenoid valves, closing both pressure and return lines to the servo motor in question. The deceleration potential of this system is greater than the maximum acceleration specification of the servo system and rapid position limiting is accomplished.

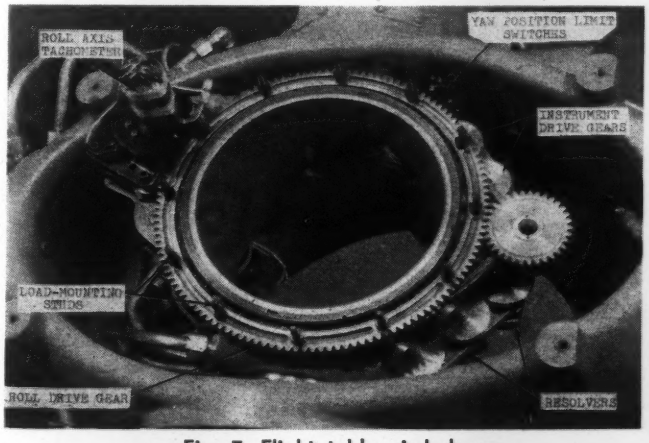


Fig. 7. Flight table gimbals.

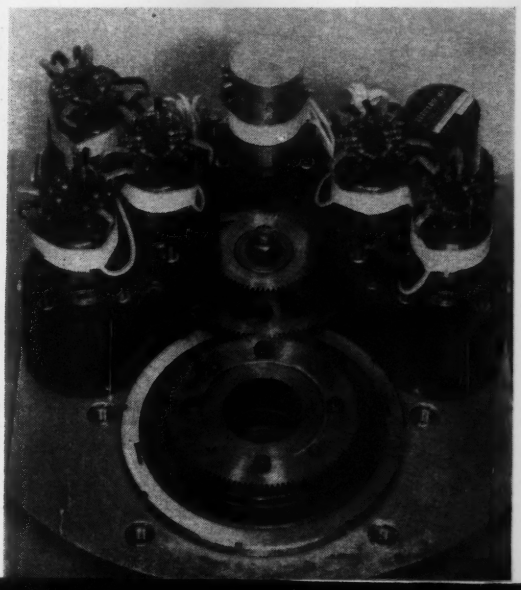
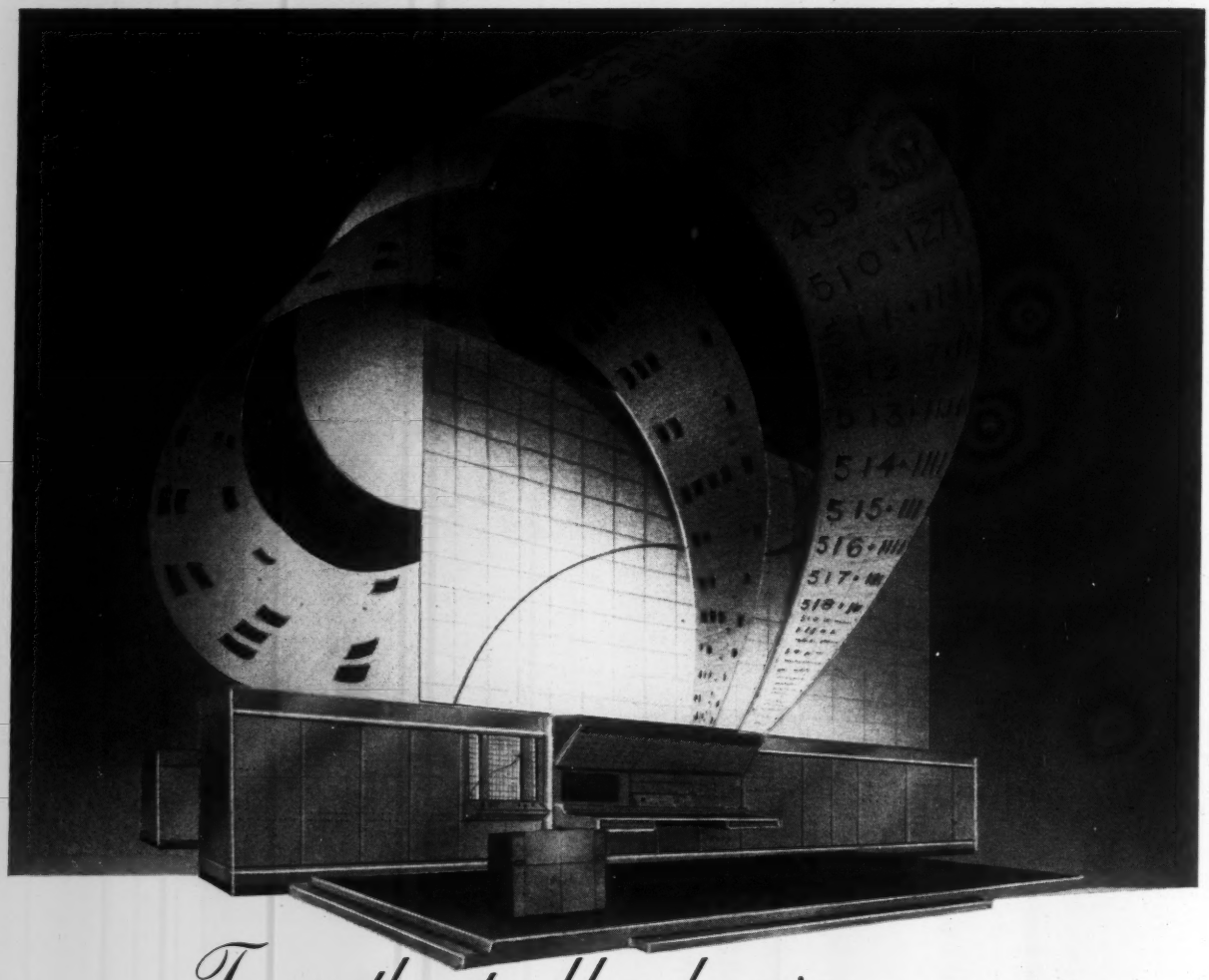


Fig. 8. Yaw-axis instrument group.



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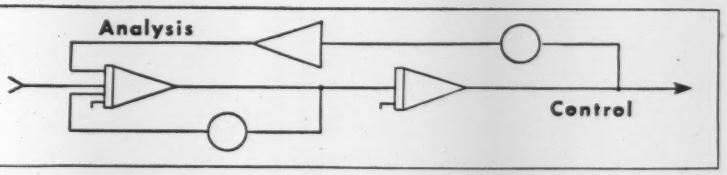

John H. McLeod, Jr., EDITOR

Suzette McLeod, SECRETARY

8484 LaJolla Shores Drive
LaJolla, Calif.

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Bits

Well! Those of you who in the past have agreed with one reader who wanted more "meat" and fewer "wisecracks" should certainly be happy with PIECES this month. Hal Coleman's notes, which are the basis (and mostly the substance) for the entire writeup were so meaty that there was no room for wisecracks. In fact I even had to delete the juiciest (mathematically) part of his writeup to conform to the objective of this column—i. e., to keep you informed of *who* is doing *what* with *which* and *why*—not *how* (nor to *whom*).

The original idea of *BITS* was to help you decide in a few words whether you would like to read further or not. Sometimes Your Editor leaves this section out for obvious reasons. However, this month I will explain that the Midwestern Simulation Council discussion involves mathematical and computer manipulations necessary to change from one frame of reference to another. Why change? Consider an airplane or guided missile. Its own longitudinal, vertical, and lateral axes constitutes one frame of reference. But the aerodynamic forces acting on it are dependent on the relationship of these axes to the atmosphere through which it flies, which constitutes another frame of reference. Thus, if you wish to go to some specific place, or hit a target on earth or in space, you are concerned with earth or space coordinates which constitute yet another frame of reference.

In simulation, many transformations from one set of coodinates to another are involved.

Pieces

MIDWESTERN S/C MEETING OF 9 JULY ON "COORDINATE TRANSFORMATION"

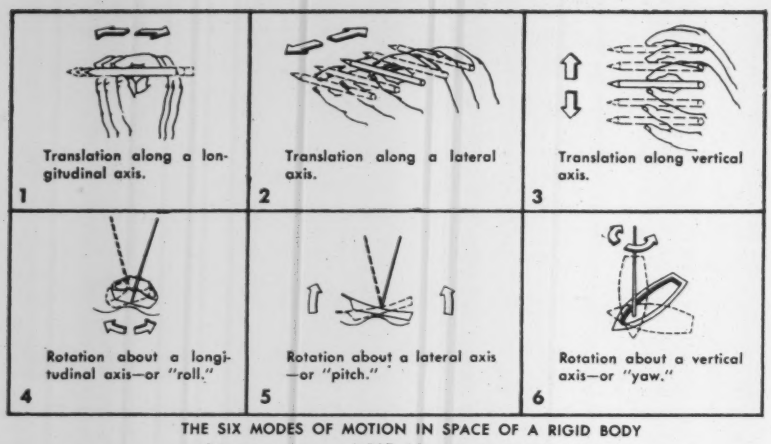
Colonel Rodger Henniem of the Detroit Arsenal welcomed the Midwestern Simulation Council on the occasion of their meeting there July 9, 1956. Colonel Henniem said that the Arsenal had been in the computer business for nearly two years, and that they are now expecting new equipment which will expand their facilities substantially. He then briefly outlined the activities of the research projects in the automotive field of the Defense Department, which includes tanks, tank destroyers, self-propelled vehicles, armoured cars, and retrievers.

Howe on Coordinate Transformation

Jim Stone (Battelle Memorial Institute, Columbus, Ohio), presiding for the last meeting of his term as Chairman, introduced *Bob Howe** (University of Michigan, Ann Arbor), who spoke on "An Introduction to Coordinate Transformations." Bob began with a discussion of what coordinate systems are available and why we need to transform coordinates. As examples he used analog computer solutions of three-dimensional aircraft problems, although many of the concepts are directly applicable to other simulation problems, such as the motion of an automobile.

To solve the three-dimensional flight equations it is necessary to assume an axis system in which to write the equations of motion. The most common is the body's system of axes. This is an orthogonal right-hand set with the x axis aligned

*See I&A, Dec. 1955, page 2099 for biography of Robert Howe.



THE SIX MODES OF MOTION IN SPACE OF A RIGID BODY

(Photo courtesy of MB Manufacturing Co.)

along the longitudinal axis of the aircraft, the y axis lateral, and the z axis vertical. Three translational equations and three rotational equations representing equilibrium forces and moments along each of the three axes can be written. (These six basic modes of motion in space of a rigid body are shown nicely in the accompanying illustration.) The inputs to the translational equations are the power plant, aerodynamic, and gravity forces, while the outputs are $\dot{u}$, $\dot{v}$, and $\dot{w}$, which when integrated give the velocity components U, V, and W(along x, y, and z) of the total aircraft velocity V_P. The translational equations are highly nonlinear, having in all six products (two each) of the form WQ, UR, PV, etc. where P, Q, and R are the components of aircraft angular velocity about x, y, and z. The inputs to the three rotational equations are aerodynamic and power plant moments, and the outputs are $\dot{P}$, $\dot{Q}$, and $\dot{R}$ which, when integrated, yield P, Q, and R.

Euler Angles Vs. Direction Cosines

From P, Q, and R and the appropriate initial conditions, the orientation of the aircraft with respect to the earth axes can be computed. This orientation can be specified by either (1) *Euler angles* or (2) *direction cosines*. It is necessary to compute this orientation in order (1) to obtain the gravity force components along x, y, and z; and (2) to compute the aircraft velocity north and east, and rate of climb.

The *Euler angles* θ (pitch), ϕ (bank), and Ψ (heading) are computed from P, Q, and R by the following formulas.

$$\dot{\Psi} = (R \cos \phi + Q \sin \phi) / \cos \theta$$

$$\dot{\theta} = Q \cos \phi - R \sin \phi$$

$$\dot{\phi} = P + \sin \theta$$

It is clear that we must be able to compute sines and cosines of the Euler angles θ and ϕ in order to solve these equations which, when integrated, give Ψ, θ, and ϕ. Hence the requirement for a trigonometric resolving circuit. The velocity north $\dot{s}_x$ and velocity east $\dot{s}_y$ also require $\sin \Psi$ and $\cos \Psi$.

The *direction cosines* l_1, l_2, l_3, m_1, m_2, m_3, n_1, n_2, n_3, also can be used to specify the aircraft orientation, and have the advantage that they do not break down when $\theta = \pm 90°$. They are computed from P, Q, and R by solving nine simultaneous first-order equations, each of which involves two multiplications. The formulas for $\dot{s}_x$, $\dot{s}_y$, and $-\dot{s}_z$ (rate of climb) are simpler in terms of the direction cosines. Because there are nine variables now used to specify orientation, there must in fact be six redundancies present, since we have already seen that only three variables (e.g., θ, ϕ, and Ψ) can specify the orientation. The elimination of the six redundancies by correction circuits adds considerable complexity to the analog-computer circuit. If the simulation is to take place over a relatively short time these corrective loops may not be necessary.

Coordinate Systems

Bob then returned to a consideration of coordinate systems. Besides the body axes x, y, and z, another coordinate system can be used for solving the translational equations. This is the *flight-path* or *wind-axis system*, often denoted by x_w, y_w, z_w. The dependent variables for this system are V_P (total velocity), α (angle of attack), and β (angle of sideslip). This immediately points up an advantage of the wind-axis system: whereas V_P, α, and β are required for aerodynamic calculations and must be computed anyway from U, V, and W in the body-axis system, they appear directly in the wind-axis solutions. Another advantage of the wind-axis equations is that they are inherently simpler.

Orientation of the wind axes can be denoted by wind-axes Euler angles θ_w, ϕ_w, and Ψ_w. These can be calculated from wind axes angular rates P_w, Q_w, and R_w by formulas identical to those for θ, ϕ, and Ψ from P, Q, and R. The equations for earth-axis velocity components $\dot{s}_x$, $\dot{s}_y$, and $\dot{s}_z$ in terms of V_P, θ_W, and Ψ_W are very simple. This is an excellent system if accurate body-axis Euler angles θ, ϕ, and Ψ are not required. Even if body-axis angles are required and used, this combined system, using wind axis for translational and body axis for rotational equations, appears to be superior to the all-body-axis system.

Solving the Transformation Equations

There are a number of methods for performing the trigonometric resolutions necessary to solve the coordinate transformation equations discussed up to now. For dc analog computers the most common uses the servo-driven sine-cosine potentiometers. Each of the pots has a resistance variation with wiper-arm angle that is not linear, but proportional to the sine and/or cosine of the wiper-arm angle. Another technique uses diode function generators to approximate the trigonometric functions by a series of straight lines. A third method is a mechanization of the equation $d^2y/d\theta^2 + y = 0$, the solutions of which are sine θ and cos θ.

Integration with respect to θ is achieved by first multiplying each integrator input by θ. The result is integrator outputs and servo shaft angles or electronic multiplier master pulses proportional to $\sin \theta$ and $\cos \theta$. To insure that $\sin^2\theta + \cos^2\theta = 1$, the error $\epsilon = 1 - (\sin^2\theta + \cos^2\theta)$ is computed and used to provide damping around each integrator. This essentially removes the one redundancy in the equation for getting θ.

Bob has used this latter technique for complete three-dimensional simulation of aircraft, including large-scale maneuvers such as rolls and loops. No resolvers as such are needed, and accuracy is essentially that of the multipliers. The Euler-angle variables are essentially preserved.

Knobelauch on Direction Cosines

Jim next introduced *Dr. Edward Knobelauch* (Naval Air Development Center, Johnsville, Penna.), who spoke on "The Use of Direction Co-

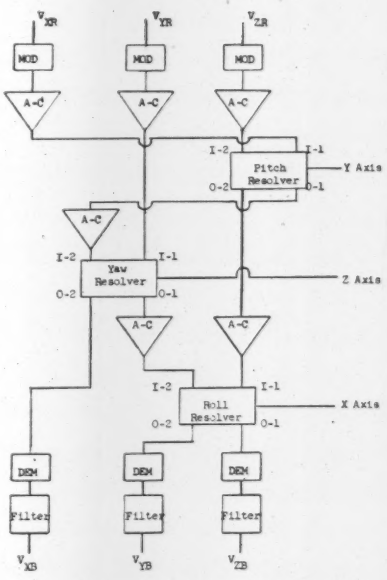
sines in Three-Dimensional Flight Simulation." The analog computer "Typhoon" was originally designed as a special-purpose analog computer to be used for three-dimensional flight simulations. Dr. Knobelauch presented an erudite discussion of the equations that relate the velocity components and their rates to the angular velocities, aerodynamic and thrust components, and their expression in terms of both direction cosines and Euler angles (which discussion is both too mathematical and too long for inclusion in this Newsletter). However, the parallel definitions and equations as presented and compared in parallel columns were interesting and we suggest that those who care to pursue the subject in detail get in touch with Dr. K.

It was concluded that the equations of motion of a rotating rigid body can be formulated directly in terms of the direction cosines without trigonometric functions of the Eulerian angles, and with all quantities finite for all orientations of the rigid body.

Digital error studies have been made comparing the direction-cosine method with the Euler-angle method. Because of a first-order error assumption, the results were considered inconclusive; however, they seemed to favor the direction-cosine method. At any rate the direction-cosine method has always been used at Typhoon. A digital reference solution is always provided to compare at least one of the runs of a given simulation problem and invariably, after the bugs of the complete simulation have been eliminated, the agreement between digital and analog has been satisfactory. It is this fact which has restrained Typhoon from changing from the direction-cosine method. However, many design changes have been made in the original Typhoon computer to keep pace with the simulation problems which have arisen. Indeed the design changes have been such that Typhoon today is a general-purpose analog computer capable of real-time mathematical simulation or a simulation incorporating physical components. So if it is necessary to abandon the direction-cosine method Dr. Knobelauch is sure that they can and will do so.

Kowlaski on Vector Transformations

Don Kowlaski (Bendix Aviation Corporation, Detroit, Mich.) next discussed "The Ability of the Flight Table to Perform Vector Transformations." He gave a brief introduction describing the Bendix Three-Dimensional Flight Simulator* which included slides of the computer and flight table. The frequency response of the flight table (for 90° phase shift: roll = 100 cps; yaw and pitch = 45 cps) and the ability of the flight table to transform four vectors and perform its own Euler-angle transformations was stressed.



One of four similar resolver chains

The flight table accomplishes vector transformations by means of a-c resolvers (Arma type 03NN400) which are mounted directly on the gimbals in order to eliminate any intermediate servo lag which would lower performance. There are fifteen resolvers on the flight table, five on each gimbal. Four resolvers on each gimbal are used for vector transformations, and one is used in the Euler-angle transformations.

A single resolver performs the following transformation:

$$O_1 = I_1 \cos A - I_2 \sin A$$
$$O_2 = I_1 \sin A + I_2 \cos A$$

where O = output, I = input, and A = angle of rotation. Using d-c resolvers to perform the same single-axis transformation would require at least three summing amplifiers, a sine pot, and a cosine pot. The physical dimensions of a resolver are: diameter 1.5 inches, and length 1.75 inches.

However, since the resolvers require a-c signals, and vector components which are to be transformed are computed on a d-c analog computer, the d-c signals must first be a-c modulated and the outputs of the resolvers must be demodulated before they can be used in the d-c section. This change from d-c to a-c and back to d-c is performed by the computer resolver chains. Each resolver chain consists of a modulator, a resolver and associated a-c amplifiers, a demodulator, and a demodulator filter. For a three-axis transformation three such chains are used, one for each component of the vector. (See schematic.)

In the resolver chain a d-c signal is applied to the modulator, which converts it into a 1000-cycle suppressed-carrier wave. This 1000-cycle signal enters the a-c amplifier and associated resolver. The a-c amplifier has phase and gain controls to assure that there is no attenuation or phase mis-match between the a-c voltages as they are being added or subtracted in the resolvers. Voltage feedback and current compensation in the a-c amplifiers assure maximum linearity and accuracy from the a-c resolvers. The output of the resolver is demodulated and filtered. D-c to d-c linearities in the vicinity of 0.1 percent are obtainable with the flight-table gimbals all at zero. With the gimbals angularly displaced, the resolver chain performs a three-axis vector transformation with an accuracy of better than 0.5 percent of full scale.

It has been estimated that if d-c resolvers were used to perform these same vector transformations, ten additional racks of equipment would be required. Because of the advantages of the a-c resolver transformation system, Bendix feels that it is a better method than one which uses "analogous" d-c equipment.

The inputs and outputs of the resolver are all accessible on a patch-board allowing each individual resolver to be used separately or in a complete three-axis transformation from either body-to-reference or reference-to-body system.

Elliott Buell (Northwestern University, Evanston, Ill.) asked whether anyone had made a study of the accuracy in the direction-cosine technique using resolvers. He wanted to know which method is superior with respect to equipment and cost.

Don Kowlaski said that he felt the resolver method is substantially

*See pages 1789-1791

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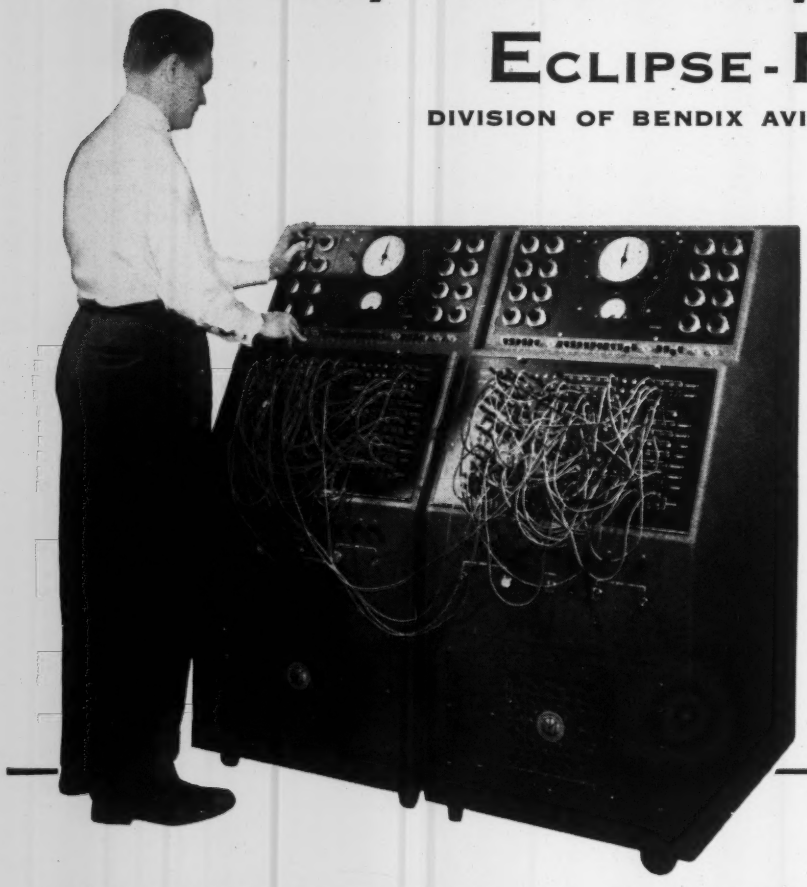

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cheaper and requires less equipment.

Quested about controlling the system by rate signals, Don indicated that there is also a position control in the system to correlate small rates and positions.

Jim Stone remarked that everything mentioned so far had been a coordinate transformation with respect to air frames, and wondered if anyone had anything to say about other coordinate transformations.

Jerry Kennedy (Electronic Associates) asked about speed limitations. Don replied that they operate on the 1:1 time scale. Jerry wondered about the time lag between the resolvers and the system. Don answered that there is direct coupling of the resolvers to the axes so that there is no time lag.

A tour of the Arsenal facilities showed the variety of phases in research and testing being conducted. Of particular interest was the computer facility, where an Electro-Data digital computer was being installed. The installation was not complete but a brief demonstration appeared very effective.

Tom Wood (Detroit Arsenal) had an analog demonstration set up that was really sharp. The outline of a tank, complete with gun turret, body and wheels, was displayed on a 21″ scope. As the tank ran over an object you could see the solutions of the equations describing the motion as the wheels bounced and the tank pitched back and forth. Almost as good as channel 7!

Information (Without Theory)

Those rebels (I can talk—I'm from New Orleans) haven't seceded after all; simply got fouled up by a damyankee!

We received a letter from *Bill Bradley* (Murphy & Cota, Atlanta, Georgia) which tells the sad story as follows:

"Dear John:

"Attached are the reconstructed minutes (from memory) of the Southeastern Simulation Council meeting at Eglin Air Force Base on March 30, 1956. A secretary was hired to take the minutes in shorthand and was supposed to have mailed these to me within a short time. About three weeks later I received a letter from her stating that she had been called back to her home in Ohio on an emergency and would transcribe the notes and forward to me as soon as she returned to Florida.

"After waiting about six more weeks, I tried to locate this secretary and found that she never returned to Florida and I could not locate her mailing address in Ohio. This accounts for the fact that we did not send you the minutes sooner . . . ."

Because Bill's notes hardly constitute a PIECE we excerpt them here as "Info":

"Seventeen members, representing eight organizations, of the Southeastern Simulation Council, met at Eglin Air Force Base on Friday, March 30, 1956. *Mr. Fred Howard* of the Air Force Armament Center acted as host, and the afternoon activities began with a luncheon at the Eglin Officers Club. A movie depicting the aims and purposes of the Air Research and Development Command was shown, followed by a tour of the AFAC facilities. This tour included the Research laboratories, Analog Computer Center, Digital Computer Center, Data Reduction Center, and the precision "Time Generator" which furnishes timing signals for the whole Eglin area . . .

"*Fred Shaver* (Redstone Arsenal, Huntsville, Alabama) discussed the evolution and history of the analog computer for the benefit of those attendees unfamiliar with analog techniques."*

"*R. W. Olive* (Lockheed Aircraft Corp., Marietta, Georgia) discussed auto-pilot simulation in design studies of aircraft.

"*R. S. Johnson* (Georgia Institute of Technology, Atlanta) discussed a unique application utilizing high-gain amplifiers and diodes to perform 'decisions' in simulation problems where polarity and not magnitude of the signal is desired to perform switching commands.

"Since this meeting was held on Friday before Easter Sunday, and insufficient number of the members desired to go fishing, the fishing trip was cancelled."

Humans Vs. Computers

The Human Engineering Society of San Diego held a meeting on July 25th in the Navy Electronics Laboratory auditorium. *Dr. J. C. R. Licklider* (Massachusetts Institute of Technology, Cambridge) discussed "The Human Being versus the Computer."

This meeting was certainly interesting to your Editor, and if I can read my notes I will give you a rundown on it next month. For now I will only say that these Human Engineers (not to be confused with humans who are engineers or vice versa) are concerned with fitting machines to their human operators. They are attempting to learn how human beings think, and this involves them in the currently fashionable sport of comparing human brains with computers.* Some human engineers know a great deal more about computers than your Ed., and some do not (I have never met a computer that knew *anything* about a Human Engineer), but all I have met have been doggoned interesting guys, so if you want into the act, this is your invitation to get in touch with me and I will see that you get further info. . .

* * *

The several Simulation Councils have voted to hold their annual meeting in conjunction with the 3rd Automation Exposition, New York, N. Y., on Wed. and Thur. Nov. 28-29, 1956. Each council will conduct one of four afternoon sessions.

* * *

Those of you using, or contemplating the use of servomultipliers may be interested, as your Editor was, in "Memorandum No. 20-118, Servomultiplier Error Study" by *Robert A. Bruns* of the Jet Propulsion Laboratory, Pasadena, California.

* * *

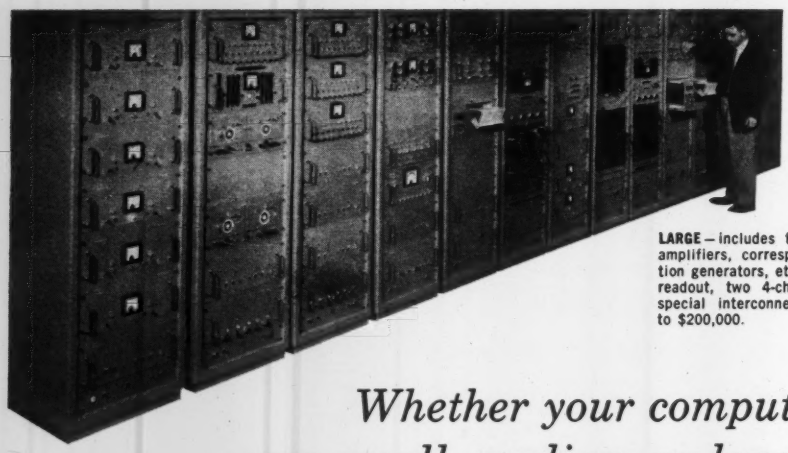
Speaking of ideas, Dr. Licklider, the MIT Human Engineer, observed: "The fun is all in the conception; the pain comes with the labor required to produce anything."

One raison d'etre of the *Simulation Council Newsletter* in *I&A* is to show industry how important analog simulation can be to industrial operations: Great editorial emphasis has been placed by the editors of I&A (Milt Aronson in particular) on this point, and our joint CIP (computer-in-plant) project has been discussed at the highest levels of many processing plants. It appears that this emphasis is about to bear fruit.

A national steel manufacturing concern (one of the big ones) has turned its attention to the possibilities of analog simulation as applied to its integrated metallurgical and manufacturing activities—and is considering the establishment of an analog computation group. This group will start analyzing the plants and their operations from top to bottom— from blast furnace opera-

* This portion of the meeting was held in conjuction with the North Florida Chapter of the IRE.—Editor's note.

*Dr. Licklider pointed out a fact that intrigued your Secretary. Throughout the ages wise men have compared the human brain to the latest technological development. In the Middle Ages pipes and pumps to remove water from mines were the last word—and the brain was also full of pipes, through which flowed humors, good and bad. Later people had brains that operated like clockwork. (Is this when we first became "all wound up"?) Today our heads are crammed with relays, transistors, and subminiature circuits. We even know some people who have been potted!



LARGE—includes two control units with 200 pots, 80 amplifiers, corresponding number of multipliers, function generators, etc., plus digital voltmeter with printed readout, two 4-channel recorders, timing matrix and special interconnecting panel. Price range, $100,000 to $200,000.

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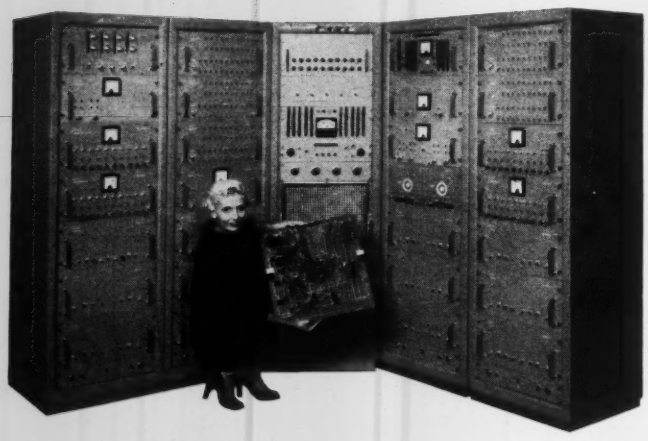

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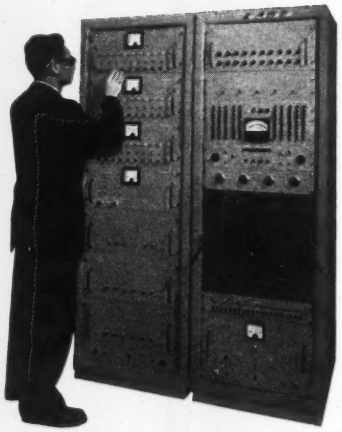

SMALL—includes control unit with 50 pots, 30 amplifiers, 2 electronic multipliers, 10 initial condition voltage sources, power supplies. Price range, $12,000 to $25,000.

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SIMULATION COUNCIL—CONT.

tions to metallurgical problems. They need a man with analog computer experience to head up the program. Anybody interested??? Contact John McLeod.

P. S. Same organization wants man to head up a "system evaluation group—a top-notch instrument man with some steel-plant background."

Computer Events

Other events on page 1742

Eastern Simulation Council
Date: 24 Sept.
Place: Moore School of Electrical Enginnering, University of Penna., Phila., Pa.
Time: 9:00-11:00 AM (tour); meeting at 11:00 AM.
Subject: Simulation by Modeling and Analogies"
Contact: Dr. Morris Rubinoff, U. of Penna., Moore School of Electrical Engineering, Phila. 21, Penna.

National Electronics Conference
Dates: 1-3 October 1956
Place: Hotel Sherman, Chicago.
Information: NEC, 84 East Randolph Street, Chicago 1, Ill.

Midwestern Simulation Council
Date: 1 October 1956 (in conjunction with NEC)
Place: Chicago, Illinois
Tammen and Dennison, Engineering Consultants and Electronic Associates will act as joint hosts
Subject: "The Use of Analog Computers in Hydraulic Simulation"

Third International Automation Exposition and Analog Computer Clinic
Dates: 26-30 November 1956
Place: New York Trade Show Bldg.
Information: Richard Rimbach Associates, 845 Ridge Avenue, Pittsburgh 12, Pennsylvania

National S/C Meeting
Dates: 28-29 November 1956
Place: In conjunction with 3rd Automation Exposition
Information: John McLeod

S/C Organizational Meeting
Date: October 15
Place: Beech Aircraft, Wichita
Information: Norm Irvine will lead discussion on Analog Computer Techniques. Group will tour Beech Computer facilities.

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Journal of the S C M A . . .

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Recent Developments in SOLENOID VALVES

Solenoids offer high speed of response in on-off valve-control applications. Power limitations are overcome by use of pilots. Here is a thorough résumé of the many types now available for valve and cylinder actuators.

FRANK E. REEVES
Automatic Switch Company

ALTHOUGH it is the purpose of this article to describe many new developments in solenoid valves, a discussion of basic types and constructions is necessary. Such a discussion will establish the terminology used.

Direct-Acting Valves

The simplest solenoid valve is a packless, direct-acting, normally-closed type (Fig. 1). Such a valve usually has a globe-type body and may be either full-pipe area or a needle valve in which the port is usually somewhat smaller than the inside cross-sectional area of the connecting pipes. There is only one moving part, plus spring.

The term "direct-acting" means that the movable core or plunger rises vertically when the coil is energized and by this action the disc is raised from the seat and the port is opened. When the solenoid coil is deenergized the movable core or plunger drops and the port is closed. The term "normally closed" indicates that when the solenoid coil is energized the port opens, and when it is deenergized, the port closes. *The term "normal," when used in an electrical sense, always means the de-energized condition.* A normally open solenoid valve would be open when the solenoid coil is deenergized.

October Meeting: *Thursday, the 18th, Rio Hondo Country Club, Downey, California.*
Feature: *Ralph Crumb, Electro Film Inc., will present a talk on "Application of Solid Film Lubricants in the Gas, Oil and Chemical Industries."*

A packless valve has distinct advantages over a packed type. In the latter type the connection between the solenoid and the valve operator must pass through some type of packing gland. Due to the limited amount of power in a solenoid, there is always a possibility of jamming of the operating stem which passes through the packing either in a straight line motion or in a rotary motion. The rotary motion has less tendency for sticking or jamming, but in either case a slight tightness of the packing or a drying out of the packing can introduce enough friction to render the valve inoperative.

In a packless type, the movable core or plunger must be immersed in the material which the valve is handling. In a valve of the type shown in Fig. 1 there must be a core tube which prevents leakage of the material being handled by the valve. This core tube must be nonmagnetic so that the magnetic flux can pass through it to act upon the movable core or plunger. Core tubes are usually of nonmagnetic stainless steel. They must have sufficient strength to withstand the pressure within the valve body. The movable core or plunger must, of course, be of magnetic material in order to be acted upon by the magnetic flux; this core can be fabricated from any of the magnetic irons or steels, but is frequently magnetic stainless steel.

Many solenoid valves must be mounted vertically with the solenoid on top in order that gravity may be used to assist in the operation of the valve when the solenoid is deenergized. However, many of the newer types of valves contain a spring-loaded plunger with the spring strong enough to return the plunger to its normal position when the coil is deenergized. Such a valve, shown in Fig. 1, can be mounted in any position.

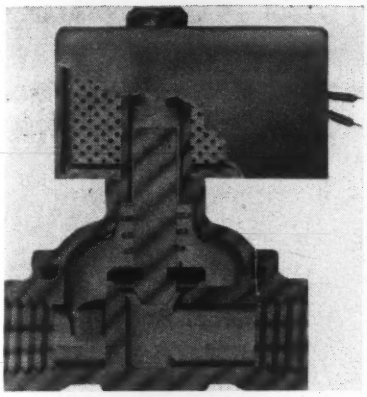


Fig. 1. Packless, full-pipe-area, direct-acting normally-closed solenoid valve (energize to open) is simplest type and is the basic valve for moderate pressures and flows. Valve can be mounted in any position because spring will close port. There is only one moving part, plus spring. The elements of the valve and the magnetic flux paths are shown in Figs. 2 and 3.

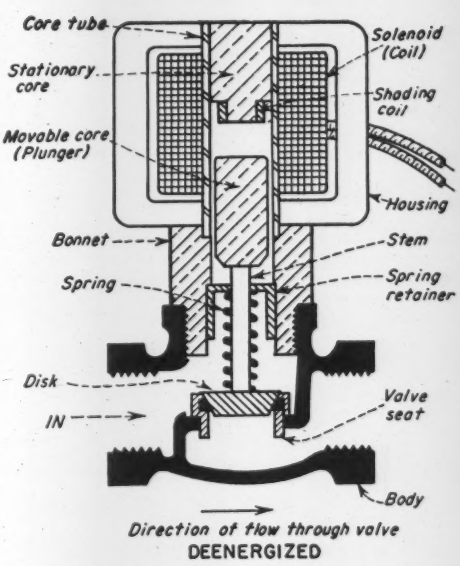


Fig. 2. When solenoid is deenergized, the spring holds valve in closed position.

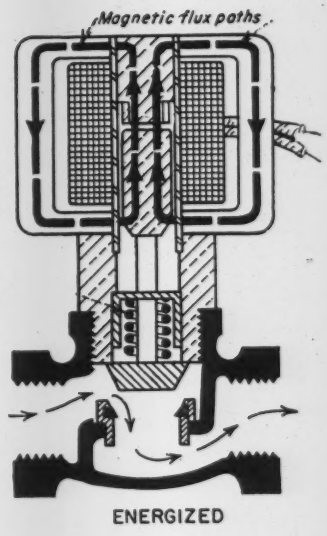


Fig. 3. Valve opens when solenoid is energized. For high pressures, pilot-operated or needle valves are required.

The Solenoid

A discussion of fundamentals would be incomplete without a mention of the solenoid. When a solenoid is designed to be used with the packless-type valve, such as shown in Fig. 1, it consists of (1) a coil and (2) a coil enclosure which acts both as a magnetic path for the flux and as a housing to protect the coil against mechanical injury or moisture. In explosion-proof valves, this housing must be capable of containing an explosion within itself without shattering and without permitting the flame from igniting a surrounding explosive atmosphere.

When *direct current* is used as a source of electric power for the solenoid, the movable core or plunger may be a solid block or cylinder of magnetic iron or steel, but when *alternating current* is used, the core either must be laminated or must have other means of preventing the circulating eddy currents. These eddy currents are of considerable magnitude and could cause the core to become excessively hot in an alternating-current magnetic field unless minimized. In the newer type of valves (to be discussed later) the plungers are magnetic stainless steel in the form of solid cylinders, and have deep slots to reduce the magnitude of the circulating eddy currents. Fig. 3 shows the path of magnetic flux when the solenoid coil is energized.

Shading Ring

As alternating current passes through zero value twice during each cycle, there is a tendency for the magnetic core to fall away from the plug nut or stationary core at these instants because the magnetic flux also passes through zero twice each cycle. In order to prevent the resultant chattering or rattling of the core, a shading ring, as shown in Fig. 2, is used. It consists of a collar or ring of copper, brass, aluminum, silver, or some other material having a low electric resistance. It can be embedded in the stationary core, as shown, or it can be mounted in the upper end of the movable core or plunger. It acts like a short-circuited turn of a transformer, and provides an out-of-phase magnetic flux which is near its maximum whenever the normal flux passes through zero. Some form of shading ring or shading coil is used in almost every type of alternating-current solenoid.

In direct-current solenoids, the magnitude of the electric current is the same regardless of the position of the movable core or plunger. However, in alternating-current solenoids the electric current is considerable higher when the air gap is larger—in other words, when the plunger is down in the position shown at left in Fig. 2. When the coil is energized and the plunger rises to close the air gap, the current drops to a much lower value. It is this condition which causes solenoids coils to burn out when the plunger remains in the lower or large gap position after the coil is energized. This happens occasionally when a valve sticks closed due to excessive line pressure above the valve's rated operating pressure, or for any other reason. It is the most common cause of coil burn-out of solenoid valves.

In a direct-acting valve the solenoid must exert sufficient force on the valve disc to open the port against the pressure drop across the body of the valve. The force exerted by the solenoid must be greater than the pressure (psi) times the area of the port (square inches). As the force produced by even a large solenoid valve is necessarily limited, direct-acting valves in the larger sizes are rated from a few psig to fractions of a psig. To handle higher pressures, the solenoid is used only to start or "pilot" the action and the pressure of the material being handled actually opens the port and closes it. Such valves are called "pilot operated."

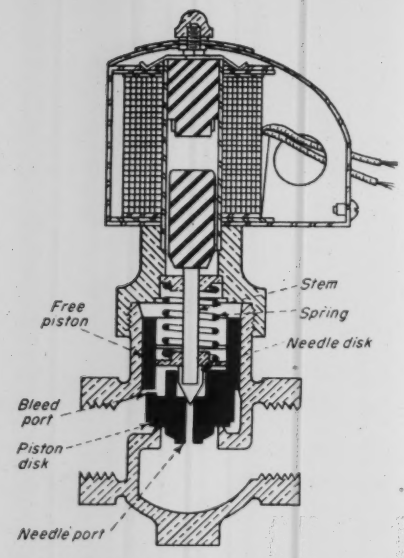


Fig. 4. Self-contained pilot-operated valve reduces the operating force required from the solenoid. Inlet pressure enters through bleed port in side of piston and exerts pressure against bottom of the disk supporting the spring on solenoid stem. When energized, plunger lifts needle disk from pilot port in center of piston. This creates lowered pressure on top of piston and increased pressure around bottom, lifting piston and opening main port.

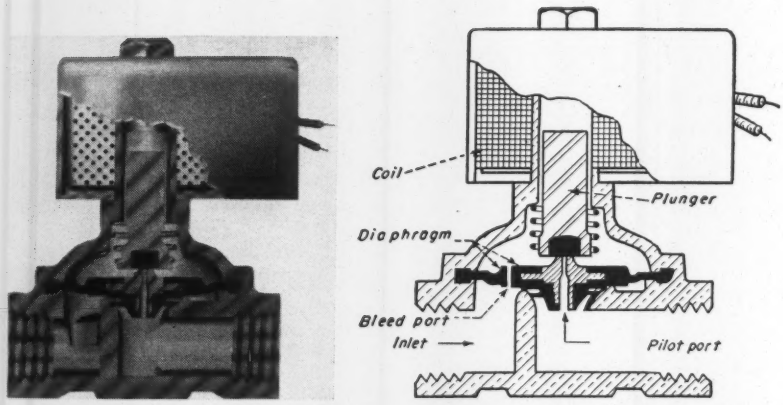


Fig. 5. Self-contained diaphragm-type pilot-operated valve. When solenoid is deenergized (as shown), pilot port is closed by seat in base of solenoid plunger. Line pressure entering bleed port holds diaphragm closed against main port. When solenoid is energized, pilot port is opened, releasing pressure on top of diaphragm; line pressure then raises diaphragm and opens main port.

Pilot-Operated Valves

Pilot-operated valves can be divided into two classes—(1) the internal- or integral-pilot-operated type and (2) the external-pilot-operated type. The most common in the former class contain a piston within the body, and one scheme to obtain operation at higher pressures is shown in Fig. 4. A small hole through the wall of the piston, known as the *bleed port*, permits the material being handled to fill the area within and above the piston, with the valve in the closed position. When the solenoid coil is energized, the plunger rises and opens a small port in the bottom of the piston called the *pilot port*. This permits the material above the piston to flow to the downstream side of the valve. The pressure above the piston is thus relieved and, because the piston diameter is larger than the main port diameter, there is an upward force exerted by the line pressure which causes the piston to lift off the seat of the main port. The pilot or needle port is larger than the bleed port so that there is always a lower pressure above the piston while the solenoid coil is energized. When the coil is deenergized, the pilot port closes and pressure builds up above the piston causing it to be forced downward to close the main port.

Another type of internal-pilot-operated valve has a resiliant diaphragm, as shown in Fig. 5. This is a newer type that operates on the same principle as the piston type. The pilot port opens when the solenoid coil is energized, permitting the flow of the material being handled through the pilot port. The pilot port, again, is larger than the bleed port, so that when the coil is energized and the plunger is in its upper position, there is a lower pressure above the diaphragm.

When the valve is in the energized condition, the diaphragm actually rides on the pressure drop across the valve body. This type of valve requires a pressure drop through the main body of at least 3 psi in order that the diaphragm may remain in the extreme upper position and permit full flow through the main port. When the pressure drop becomes less than this value, the diaphragm tends to lower and close the main port. If there is no pressure drop (no flow through the main port) the diaphragm closes the main port even though the solenoid coil is energized and the plunger is in the extreme upper position. This valve can be mounted in any position because the spring is strong enough to maintain the pilot port in the closed position regardless of the position of the valve.

The diaphragm is fabricated of Hycar or Buna N. The resilient disc in the plunger is also of Hycar. This material was developed for the petroleum industry to handle crude oil and will operate satisfactorily in ordinary liquids, gases and chemicals without rapid deterioration. The plunger disc holder and spring are of stainless steel, the plunger being deeply slotted to minimize eddy currents. The body and metal insert in the diaphragm can be either brass or stainless steel, depending on the service. Such valves will withstand and operate against relatively high pressures of up to 500 psig or more because the full pressure drop across the valve is never impressed on the resilient part of the diaphragm. Actually, the pressure across the resilient part of the diaphragm is limited to a few psi.

Fig. 6 shows a recent design of a diaphragm-operated internal-pilot-controlled solenoid valve, size ¾″x 1″ full-pipe-area type.

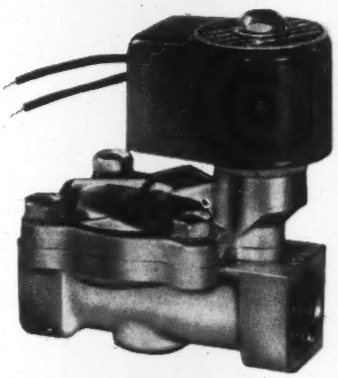


Fig. 6. New 3/4" and 1" internal-pilot-controlled resilient-diaphragm-operated, packless solenoid valve.

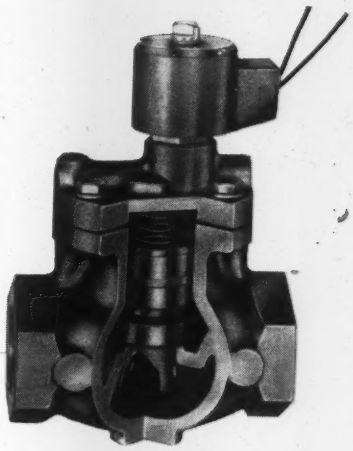
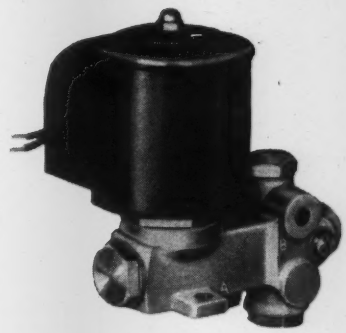


Fig. 7. Small solenoid controls large valve by opening a bypass to the downstream side of the normally closed valve.



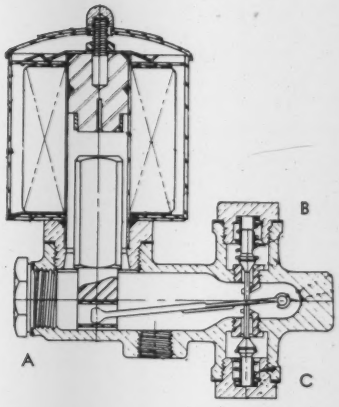


Fig. 8. Three-way solenoid-operated valves are used commonly to control cylinders and large diaphragm-type valves.

Another new development, shown in Fig. 7, is used in the larger sizes from 1¼" to 3". This valve employs a small solenoid requiring only approximately 10 watts of power to control pressures up to 200 psig or more. While operating on approximately the same principle as the previously described internal pilot valve having the internal piston, in this valve there is no mechanical connection between the piston and the solenoid plunger. Again there is a hole through the piston wall called the "bleed port," but instead of having the pilot port in the bottom of the piston, the solenoid plunger, when the coil is energized, opens a bypass to the downstream side of the valve, This pilot port in the bypass must, of course, be larger than the bleed port through the wall of the piston. Although some of the valves described previously would operate under "no pressure drop" conditions, this new valve must have a pressure drop of at least 5 psi to open and remain fully open. After the main port opens, the piston rides on the pressure drop through the valve.

Advantage of this type of valve is that it can be mounted in any position. This permits its operation in a vertical pipeline. Previous to development of this valve, it was necessary to resort to a packed-type valve for such mounting.

Another advantage of this type of valve is that it may be supplied in normally-open construction. In this construction, pressure from the upstream side of the main body is piped to the top of the midget three-way pilot. In such valves there is no bleed port through the wall of the piston, and in the deenergized condition the pressure above the piston is relieved by a continuous opening to the downstream side of the valve. When the solenoid coil is energized, the bypass from the top of the piston is closed to the downstream side of the body, and the pressure builds up above the piston to close the main port.

An additional advantage of this construction is that explosionproof or weatherproof solenoids can be supplied at small extra cost because the solenoid is always small regardless of the size of the main valve body.

The speed of opening or closing of these new valves can be adjusted by throttling the bypass cavities through the castings and also, in the normally-closed type, by adjusting the size of the bleed port. Water hammer is reduced considerably by using V ports which provide gradual shut-off as the piston moves downward (Fig. 7).

Three-Way Valves

Used principally to control single-acting air or hydraulic cylinders and larger diaphragm-type valves, three-way valves have three pipe connections and two ports (Fig. 8). The force created by the solenoid (whose plunger has a relatively large movement) is converted into a stronger force (due to the mechanical advantage of lever) necessary to open or close the ports. These ports are in the form of small needle valves, with spring-loaded discs. The cone-shaped needle discs are usually of stainless steel. Where metal-to-metal seating is required, they

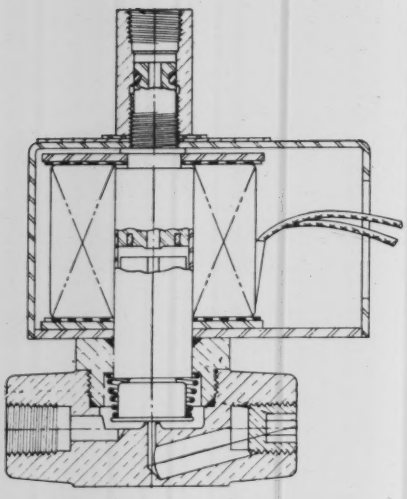


Fig. 9. In this 3-way midget valve flow is either straight through the body or around the magnetic core and out the outlet at top.

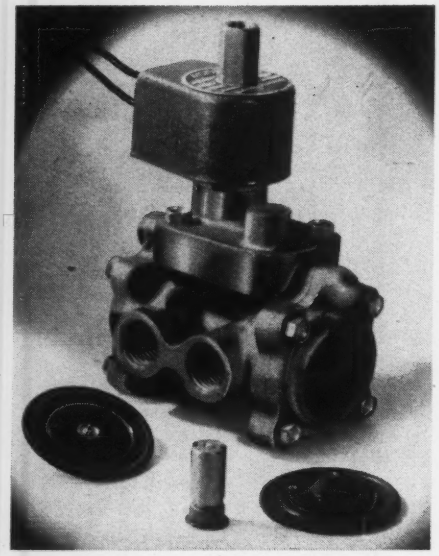


Fig. 11. Very recent development is 3-way diaphragm-type valve controlled by midget solenoid-operated pilot. Type A (left) has top outlet open to atmosphere; Type B (right) has top outlet piped back into the valve body.

may be ground into the renewable metal seats. Where tight shut-off is important, the renewable seats are equipped with resilient "O" rings.

When the solenoid coil of the valve in Fig. 8 is energized, the plunger rises and the upper pilot disc is raised while the lower disc closes. When the solenoid coil is deenergized, the upper disc closes and the lower one opens.

Pressure can be applied at the upper pipe connection B, the lower pipe connection C, or the main body connection A to give 4 forms of flow conditions (Fig. 10). Form 1 is by far the most common and is used to drive a single-acting piston or the diaphragm of a larger valve (when the solenoid is energized) and bleed the piston or diaphragm when the solenoid is deenergized. Form 2 is used when it is required that the piston or diaphragm be bled under the energized condition and pressure applied under the deenergized condition. Form 3 is used when pressure is to be diverted from one point in a system to another under the energized and deenergized conditions. Form 4 is used frequently in applications such as water-treatment plants where two different chemicals are fed into a system alternately on a time or volume-of-flow basis.

SOLENOID	PRESSURE APPLIED AT			
	A	B	C	B and C
DEENERGIZED				
ENERGIZED				
	FORM 1	FORM 2	FORM 3	FORM 4

Fig. 10. Flow paths through a three-way solenoid valve showing the common pipe connection at A and controlled ports B and C.

A somewhat new development is the midget three-way valve shown in Fig. 9. With the solenoid energized, flow is straight through the body; when deenergized, flow is through and around the magnetic core, through the upper port at top of Fig. 9. Pressure can be connected at any of the three connections, but maximum operating pressures will vary depending on where pressure is connected. In the midget construction, the pipe and port connections are necessarily limited to the small sizes.

A very new development in three-way valve construction (Fig. 11) essentially combines the bodies of a normally open and normally closed resilient-diaphragm-type valve, but uses only a midget solenoid pilot valve to control it. This valve is available in $\frac{3}{8}$" or $\frac{1}{2}$" pipe size, but in either case has a full $\frac{5}{8}$" port. It is available in two forms of flow conditions. In Form 1, which may be termed "normally closed" because pressure is shut off under the deenergized condition, the cylinder or diaphragm is bled to exhaust. When the solenoid is energized, the exhaust is closed off and pressure feeds the cylinder or diaphragm of the equipment being controlled by the valve. Form 2 is termed "normally open" because the reverse conditions prevail. When the solenoid is deenergized, pressure is applied to the cylinder or diaphragm of the equipment being controlled, and when energized, the cylinder or diaphragm of the equipment being controlled is opened to exhaust and pressure is closed off. As in the two-way diaphragm-type valve, at no time is full line pressure impressed across the resilient parts of the diaphragm. For this reason this valve can be used at pressures up to 250 psig. Available in two types, exhaust can be either piped or bled to atmosphere. In Type A, the top of the pilot valve is open to atmosphere; in Type B, it is piped back into the valve body.

Another new and interesting valve (Fig. 12) of the packed type uses a hydraulic or pneumatic cylinder controlled by a three-way midget pilot valve. This valve is available in pipe sizes from $\frac{1}{2}$" to 2" and is particularly suitable for handling corrosive gases, liquids and steam.

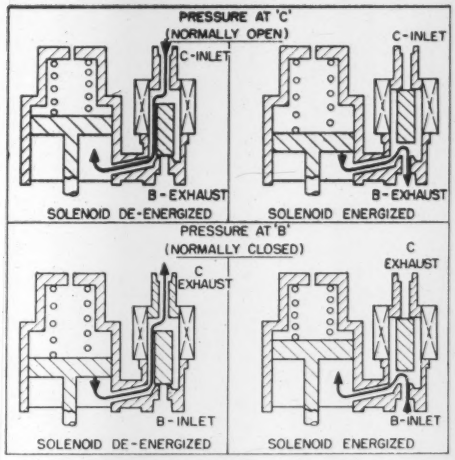
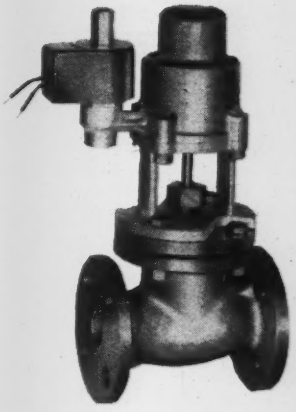


Fig. 12. Three-way midget pilot valve controls cylinder-type valve actuator.



It is a full-pipe-area valve and requires a separate source of either air or liquid for operation of the cylinder. The same valve can be used for either normally open or normally closed service, depending on the connections of pressure to the three-way midget pilot valve. As in all cases where midget pilot valves are used, explosionproof or weatherproof construction of the solenoid can be supplied at small extra cost.

Four-Way Valves

Used principally for the control of double-acting air or hydraulic cylinders, four-way valves are offered in a wide variety of types. Perhaps the simplest type, shown schematically in Fig. 13, is the balanced piston type. This again is a packless valve.

The weakness of this type of valve is that the piston is closely fitted and tends to jam if there is any pipe strain on the body. Also, there is bound to be some leakage of air. However, this valve has been used successfully on gasoline fueling of certain types of aircraft in air bases all over the world. It is available in pipe sizes from ¼" to ¾".

For larger pipe sizes and port sizes, a poppet-type diaphragm valve is offered, as shown in Fig. 14. This valve is available in pipe sizes from ¾" to 1½".

Differential-Piston Valve

A vast improvement in four-way valve design is the *differential-piston-type* four-way valve shown in Fig. 15. This valve is a relatively new development and is avail-

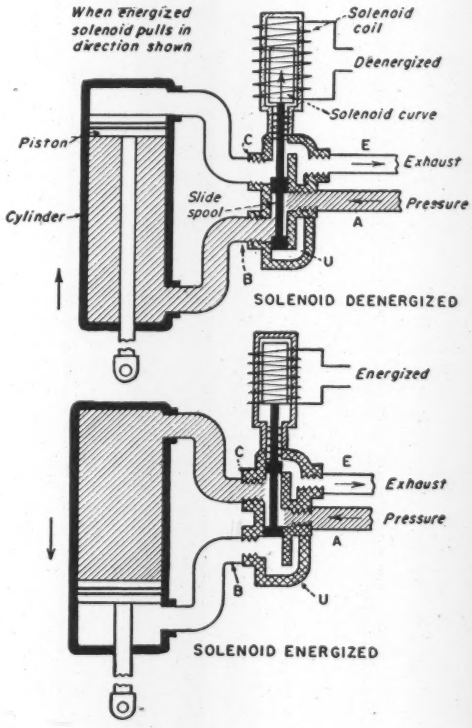


Fig. 13. Typical application of a four-way solenoid valve is control of double-acting cylinder.

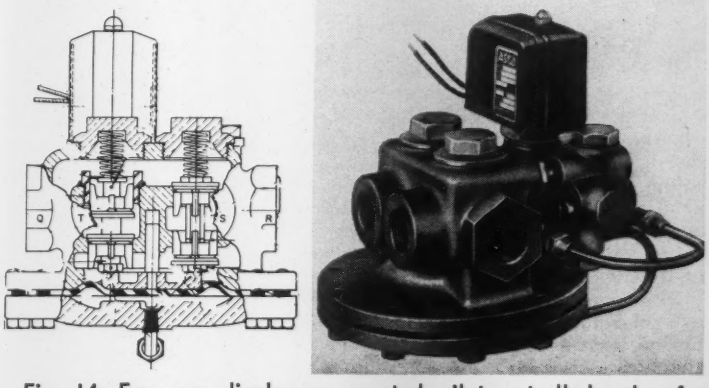


Fig. 14. Four-way diaphragm-operated pilot-controlled valve for larger pipe sizes (¾" to 1½").

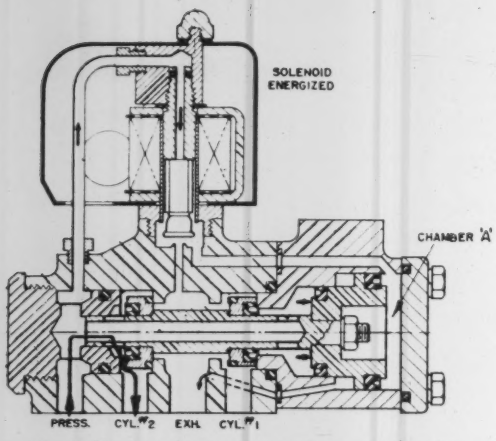


Fig. 15. Differential-piston-type 4-way valve uses hollow horizontal shaft attached to differential piston.

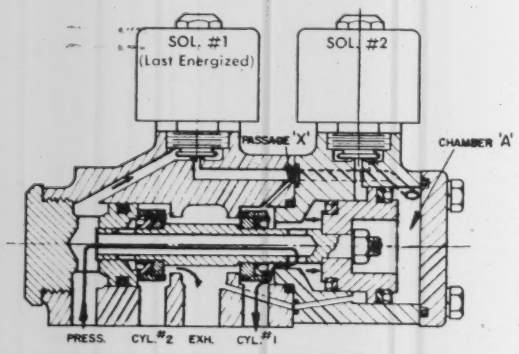


Fig. 16. Differential-piston-type 4-way valve with two solenoids.

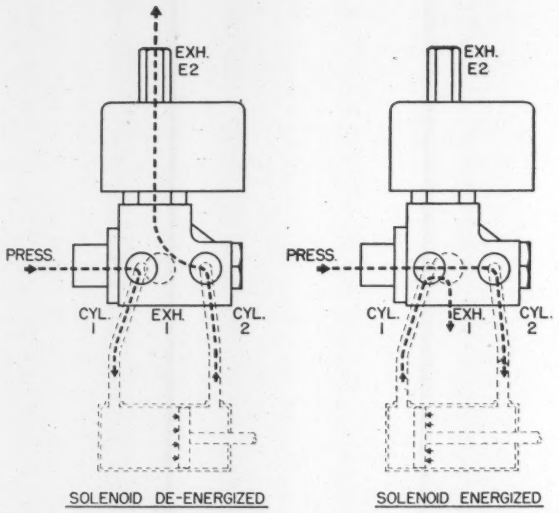
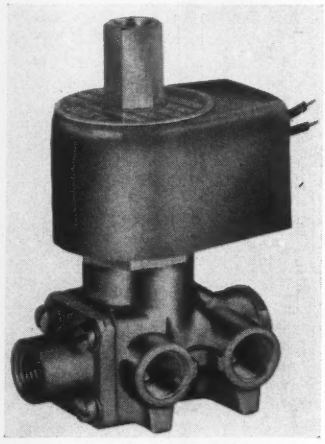


Fig. 17. This midget 4-way valve has 5 pipe connections.



able in $\frac{3}{8}$" pipe size, but will be available in the near future in larger sizes. The operating shaft, which passes through the body of the valve from left to right, is attached to the differential piston and is hollow. There is always pressure on the small end of the differential piston; with the solenoid pilot deenergized, pressure feeds around through the three-way pilot valve on top, to the large end of the piston in chamber A. This will drive the shaft to the left, closing the port which would feed pressure to cylinder #2 on the left hand end of the shaft, and open the port to feed pressure to cylinder #1. The number 2 end of the cylinder will exhaust to atmosphere through the center exhaust port. When the coil of the solenoid pilot is energized, pressure is closed off from chamber A and on the right-hand large end of the differential piston; and this chamber is exhausted to the center pipe connection marked exhaust. The left hand main port is open, feeding pressure to the #2 end of the cylinder and the right hand port is closed, cutting off pressure to the #1 end of the cylinder, and this end of the cylinder is exhausted.

This newly developed valve is available also with two solenoids, as shown in Fig. 16. The differential piston operates as in the single-solenoid unit, pressure being always applied to the small end of the cylinder, and the large end of the differential piston is either exhausted or pressurized, depending on which solenoid is last energized. The solenoid coils may be energized momentarily or continuously but, of course, the #1 solenoid must be deenergized before the #2 solenoid is energized, and vice versa.

These valves are suitable for use on air, gas, water, and hydraulic fluids up to 500 psig. "U-cup" seals are used on the differential piston and to seal the main ports. The bearing of the main ports is metal to metal with resilient material used only for sealing but not for bearing. "O" rings are not used on sliding parts, but are used as pressure seals on fixed parts of the body castings. Midget solenoids are again used on this valve, resulting in minimum cost of explosionproof or weatherproof enclosures for the solenoid coils. J.I.C.-approved enclosures for the solenoids are also available.

Another recently developed 4-way valve is the midget shown in Fig. 17. Controlled by the three-way midget valve, this unique valve has a forged brass body with five pipe connections. Use of this valve to control a double-acting cylinder is shown schematically.

This is an inexpensive four-way valve, but its ports are limited to the area of a 1/16" pipe with $\frac{1}{4}$" pipe connections. The application of the valve would be limited to controlling the cylinder of approximately 1" diameter and 1' length. Slow operation of cylinders of larger diameter and length would result if this valve were used for control of such equipment.

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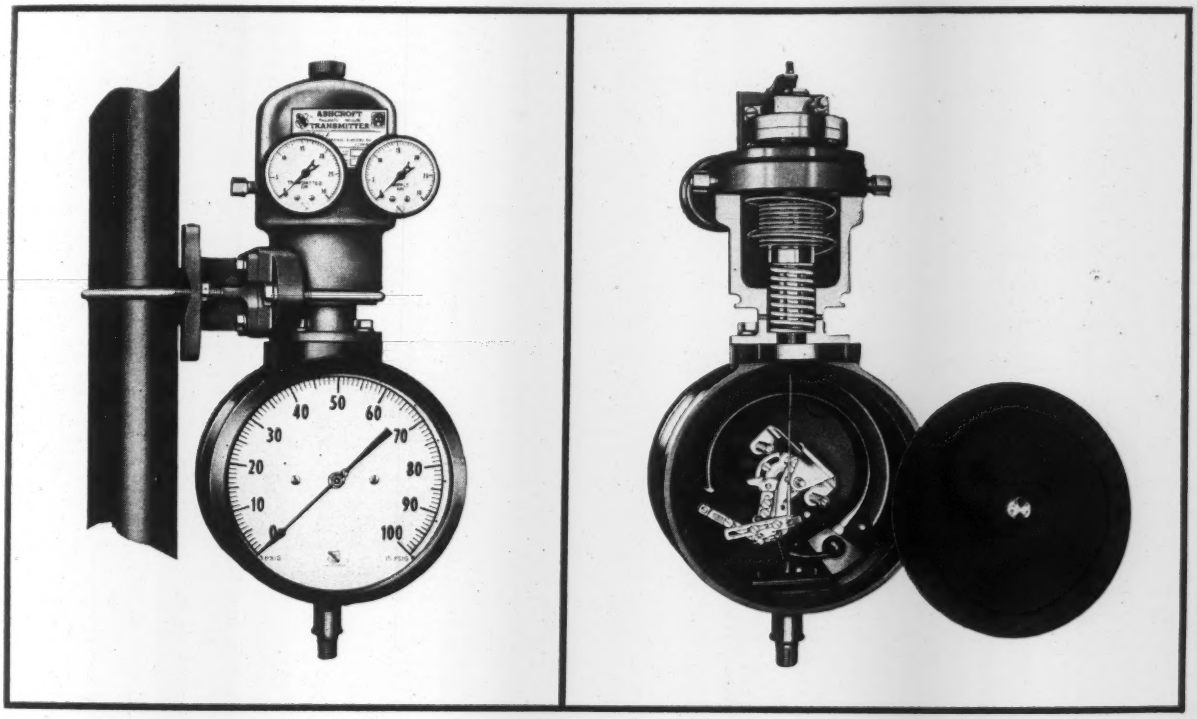

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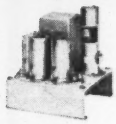
Frequencies: 240 to 1000 cycles
Accuracies:—
Type 50 (±.02% at —65° to 85°C)
Type R50 (±.002% at 15° to 35°C)
Double triode and 5 pigtail parts required
Input, Tube heater voltage and B voltage
Output, approx. 5V into 200,000 ohms

FREQUENCY STANDARD
TYPE 50L



Size 3¾" x 4½" x 5½" High
Weight, 2 lbs.
Frequencies: 50, 60, 75 or 100 cycles
Accuracies:—
Type 50L (±.02% at —65° to 85°C)
Type R50L (±.002% at 15° to 35°C)
Output, 3V into 200,000 ohms
Input, 150 to 300V, B (6V at .6 amps.)

*3½" high
400 to 500 cy.
optional

PRECISION FORK UNIT
TYPE 2003

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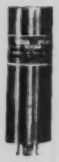
Frequencies: 200 to 4000 cycles
Accuracies:—
Type 2003 (±.02% at —65° to 85°C)
Type R2003 (±.002% at 15° to 35°C)
Type W2003 (±.005% at —65° to 85°C)
Double triode and 5 pigtail parts required
Input and output same as Type 50, above

FREQUENCY STANDARD
TYPE 2005

Size, 8" x 8" x 7¼" High
Weight, 14 lbs.
Frequencies: 50 to 400 cycles
(Specify)
Accuracy: ±.001% from 20° to 30°C
Output, 10 Watts at 115 Volts
Input, 115V. (50 to 400 cycles)



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TRANSISTORIZED

Size 1½" dia. x 4½" H. Wght. 7 ozs.*
Frequencies: 240 to 1000 cycles
Accuracies:—Same as 2003, above
Type 2007S—Silicon type
Input, 28V.
Output, Multitap, 75 to 100,000 ohms
*3½" in 2007S, 400 to 800 cycles.

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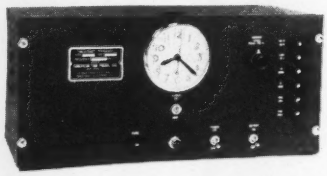
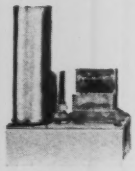


Size
8¾" x 19" panel
Weight, 25 lbs.
Output: 115V
60 cycles, 10 Watt
Accuracy:
±.001% from 20° to 30°C
Input, 115V (50 to 400 cycles)



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Size 3¾" x 4½" x 6" H., Wght. 26 oz.
Frequencies: 200 to 3000 cycles
Accuracy: ±.001% at 20° to 30°C
Output: 5V. at 250,000 ohms
Input: Heater voltage, 6.3 - 12 - 28
B voltage, 100 to 300 V., at 5 to 10 ma.

FREQUENCY STANDARD
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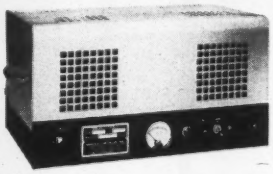
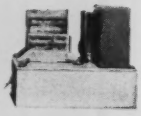


Size, with cover
10" x 17" x 9" H.
Panel model
10" x 19" x 8¾" H.
Weight, 25 lbs.
Frequencies: 50 to 1000 cycles
Accuracy: (±.002% at 15° to 35°C)
Output: 115V, 75W. Input: 115V, 50 to 75 cycles.



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D—For low frequencies
counter type, 40-200 cy.
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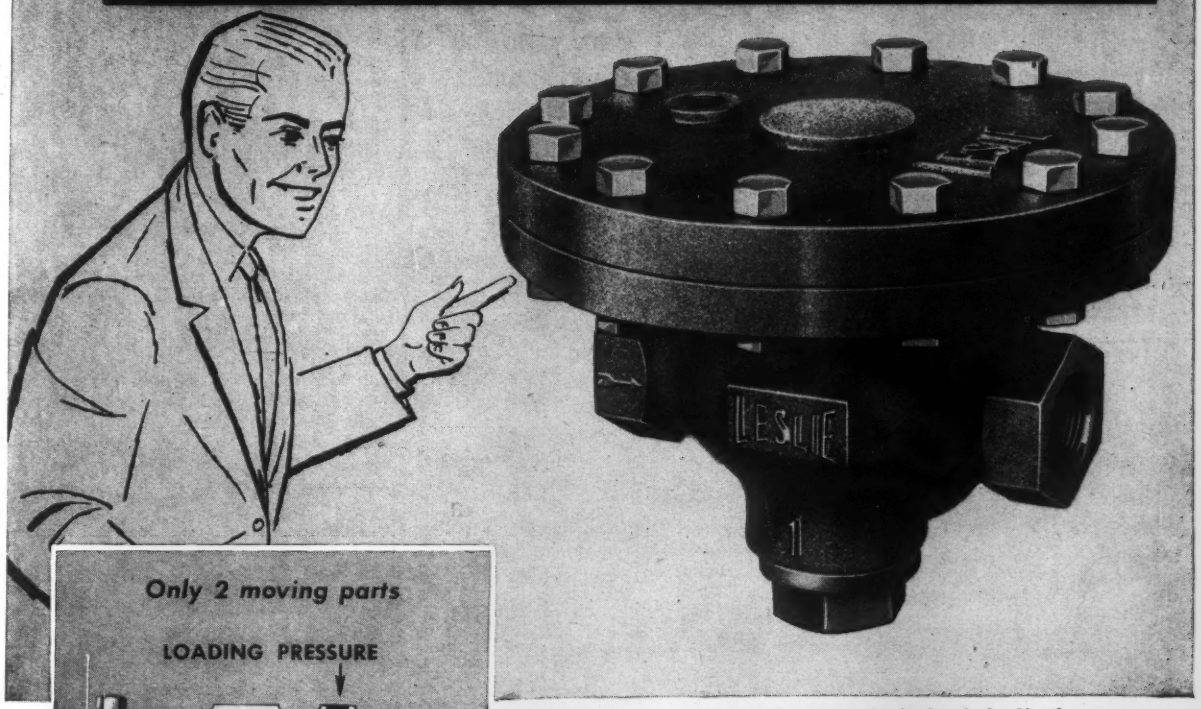

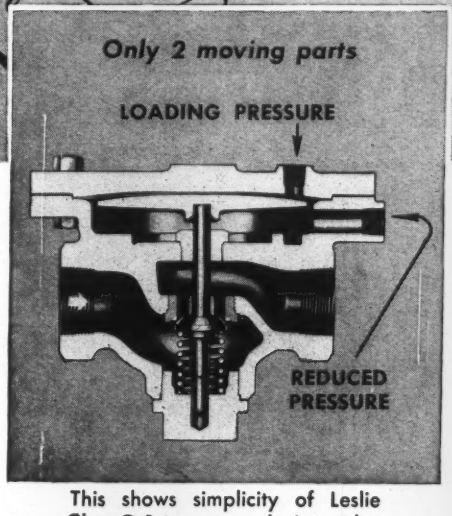

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CONTENTS OF THIS DEPARTMENT

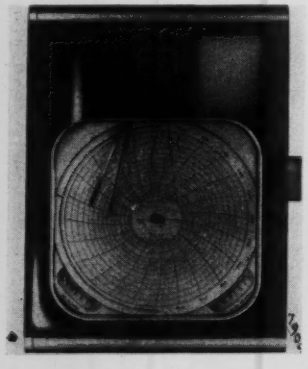
Amplifiers 1843
Capacitors 1846
Computing 1822
Counting 1819
Data Processing 1822
Dimensional Gaging and Inspection 1827
Electrical Components 1845
Electrical Instruments 1836
Electrical Testing 1832
Electrical-instrument Accessories 1841
Electromechanical Components 1850
Electronic Components 1847
Electronic Instruments 1836
Fixed Resistors 1845
Force 1814
Humidity 1813
Laboratory Equipment 1858
Load 1814
Mechanical Components 1853
Mechanical Testing 1829
Miscellaneous 1863
Nucleonics 1857
Optics 1856
Power Supplies 1843
Pressure 1817
Process Measurement and Control 1810
Relays 1851
Shop Equipment and Supplies 1826
Speed 1819
Switches 1850
Temperature 1813
Time 1819
Vacuum 1817
Valves 1854
Voltage Dividing Resistors 1845
Weight 1814

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 1891

PROCESS MEASUREMENT and CONTROL

HIGH-STABILITY WIDE-BAND PNEUMATIC CONTROLLER

New "Series 500" features high stability of control action without loss of sensitivity. Available control modes

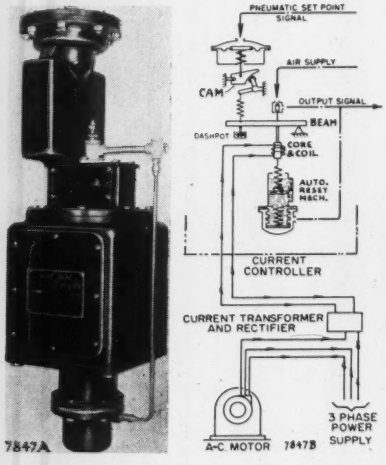


include narrow-band (on-off), proportional, reset, derivative, and reset plus derivative. Cascade, selective, ratio control, and program control models are also available. Among design features are ½% to 400 % proportional band with easy shift in width, full zero derivative setting on triple-mode controller, reset action stops for prolonged deviation from set point under severe load changes, and easy reversal of action.—*The Bristol Company, Waterbury* 20, *Conn.*

For more information circle **201** on inquiry card.

AC CONTROLLER

New electropneumatic controller uses no vacuum tubes or transistors. By measuring current flowing and

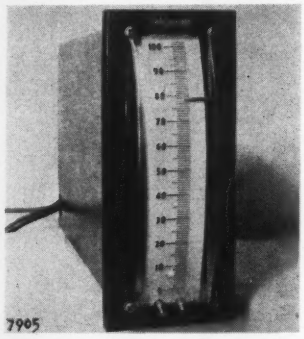


converting measurement to a pneumatic signal, it has all advantages of pneumatic instrumentation. It can limit current to a predetermined maximum or it can maintain current at a set-point value in a control system. In measurement applications its pneumatic output is a 0-30 psi signal which can be either linear or nonlinear with load. As a controller, set point can be established locally by manual adjustment or remotely by pneumatic adjustment. Instrument is a nominal 5-amp device; accuracy 0.1 amp and repeatability better than 0.05 amp.—*Hagan Corp., Hagan Building, Pittsburgh* 30, *Pa.*

For more information circle **202** on inquiry card.

VERTICAL-SCALE INDICATOR

New low-cost miniature 6" vertical-scale indicator for use with differential-transformers, resistance bulbs,

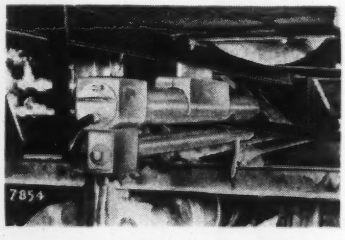


and thermistors, is servo-driven and hence more accurate and positive than deflection type. Semi-null balance circuit obviates need of line voltage stabilizing. Fail-safe feature drops pointer to zero. Indicator can be equipped for automatic control service, or fed into a secondary indicator. Repeatability 0.5% or better. Standard scale 0-100; scales for displacements, temperatures, etc., to order.—*Automatic Temperature Control Co., Inc.,* 5200 *Pulaski Ave., Philadelphia* 44, *Pa.*

For more information circle **203** on inquiry card.

BETA-RAY GAGE

New "Betameter" employs beta radiation for extremely accurate measurement of mass per unit area



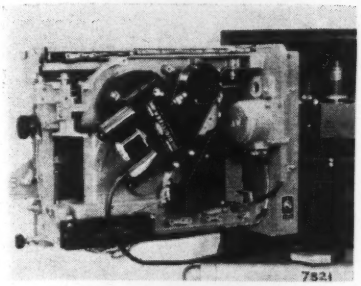
of material without contacting material; can be used to measure and control sheet thickness, basis weight, coatings, etc. Exclusive feature is use of null-balance principle whereby signal from detector is balanced against a standard signal from a second source and detector inside instrument. Photo shows strip-distributed radiation source to provide average sample measurement to minimize effect of point variations; and traversing head.—*Isotope Products, Inc.,* 1700 *Niagara St., Buffalo, N. Y.*

For more information circle **204** on inquiry card.

DIGITAL CONVERSION KITS

New "Digitizer Kits" can be connected to Minneapolis-Honeywell "Electronik" null balance recorders

Correction.—Printer's error in last line of item on Liquidometer Corp.'s mag-amp relay (August issue, page 1642). It should read *Long Island City* 1, *N. Y.*

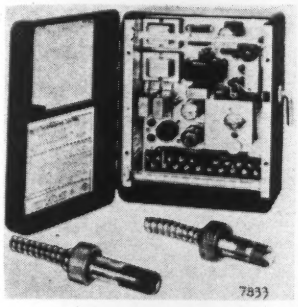


to feed Clary Printer, punched cards, and perforated tape machines. Kits can be installed in a few minutes without machining. Existing recording method remains unchanged for direct comparison with digital data. *Coleman Engineering Co., Inc.*, 6040 *W. Jefferson Blvd., Los Angeles* 16, *Calif.*

For more information circle **205** on inquiry card.

COMBUSTION CONTROLLER

New "Fireye System FP-2 Model 1012" primary control programs and safeguards entire operating sequence

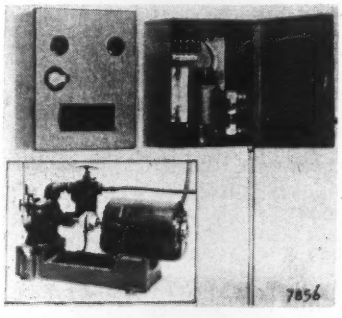


of fully-automatic rotary register oil and gas burners; uses two flame-sensitive "Firetron" scanners: one monitors pilot flame and supervises light-off sequence, the other safeguards main flame. System has both UL and FM approval.—*Electronics Corp. of America, Dept. CN-3, 718 Beacon St., Boston* 15, *Mass.*

For more information circle **206** on inquiry card.

GAS SAMPLER

New "Sample Drawing Accessory" maintains continuous guard against explosions in areas of extreme temperature or inaccessible locations of maker's "Model E" combustible gas



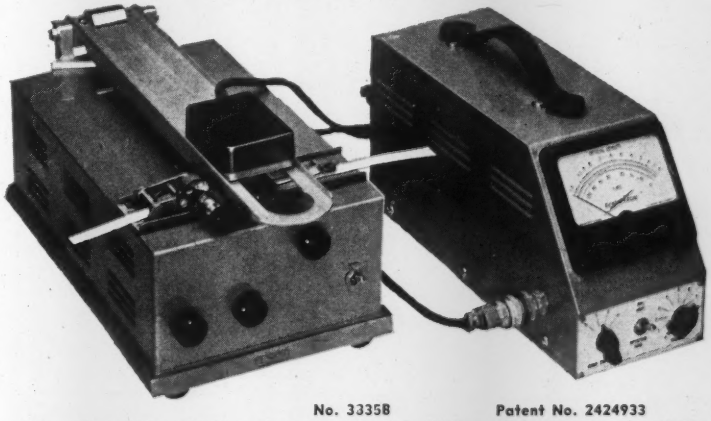
The Welch **DENSICHRON** ®

TRANSMISSION DENSITOMETER

Gives Exceptional Results In Micro-Analysis

QUANTITATIVE PAPER CHROMATOGRAPHY

Consists of Densichron, Probe, and Transmission Light Source



No. 3335B **Patent No. 2424933**

It has been found that, because of the differential migration of the solutes through filter paper the maximum color density of the paper is proportional to the concentration of material. The "no drift" feature and the high sensitivity of the Densichron provide measurements of excellent repeatability with accuracies having high statistical significance. It has been successfully used for animo acids, sugars, vitamins, steroids, hormones, drugs, and an endless variety of both organic and inorganic compounds.

TRANSMISSION LIGHT SOURCE UNIT. This is an enclosed light source powered by a constant-voltage transformer and equipped with a hinged arm for supporting the Densichron probe. The plate or film to be observed is placed over the aperture and the probe is lowered into position for a reading. Suitable controls are provided. It operates on 115 volts; 60 cycles A.C.

DENSICHRON WITH BLUE OR RED PROBE. This consists of the amplifier with logarithmic-scale meter, blue or red sensitive probe, metal probe support, five different measuring apertures, a cone with 1/8-inch aperture, and a set of instructions. The amplifier operates on 115 volts, 60-cycle A.C., only, except on special order.

No. 3835B Complete $425.00

Write for literature describing the production of papergrams and the use of the Densichron for quantitative determination by the maximum density method.

W. M. WELCH SCIENTIFIC COMPANY

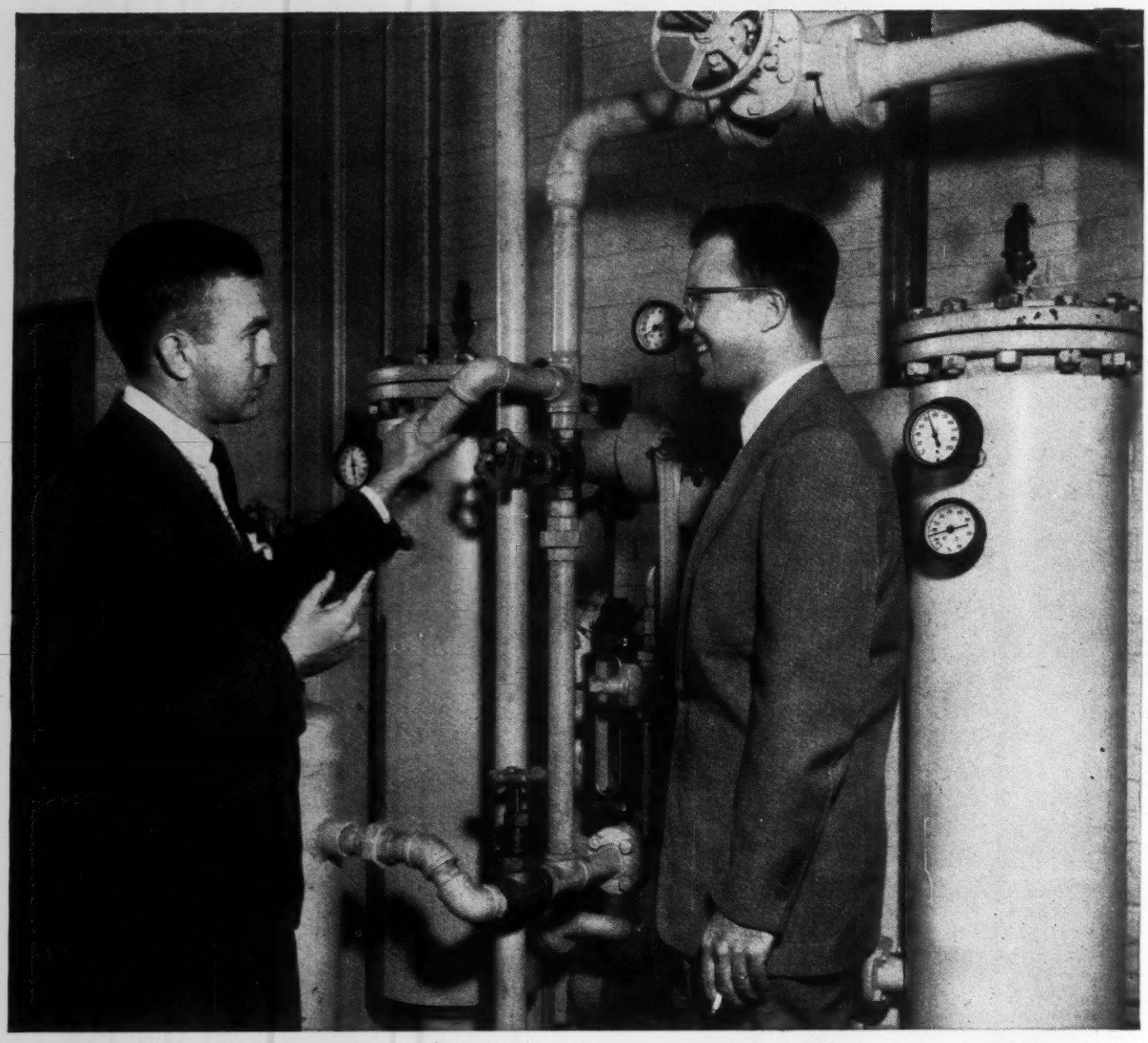
DIVISION OF W. M. WELCH MANUFACTURING COMPANY

ESTABLISHED 1880

1515 Sedgwick Street, Dept. B Chicago 10, Illinois, U. S. A.

Manufacturers of Scientific Instruments and Laboratory Apparatus

For more information circle **59** on inquiry card.



"Is this that Pritchard Hydryer you've been raving about, Ben?"

"Yes, and isn't it a honey?"

"You're pretty happy about it aren't you?"

"You bet I am. Remember those few months before we got our Hydryer? Those nights and weekends we had to work trying to keep all those precision instruments operating. If it wasn't moisture that was fouling things up, it was corrosion."

"I remember only too well. Say, Ben, how did you get a line on that Pritchard Hydryer in the first place?"

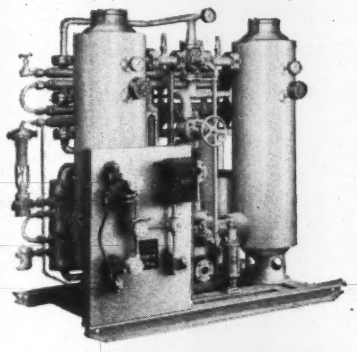
"I sent for a copy of their bulletin on the Hydryer. After I read it I talked it over with the chief and we ordered ours. You know this unit does everything their literature said it would. Right now we're pulling 63 pounds of water from our instrument air every day. It dries 160 SCFM at 100-psig., and 90°F."

"All I know is that things are a lot different around here since we put that Hydryer in. C'mon, let's go home. That air is in good hands."

J. F. PRITCHARD & CO. OF CALIFORNIA
4625 Roanoke Parkway, Kansas City 12, Mo.

For more information circle **60** on inquiry card.

"Is this that Pritchard Hydryer you've been raving about, Ben?"



PRECISION INSTRUMENTS DEMAND DRY AIR

The PRITCHARD HYDRYER* DELIVERS IT!

The Pritchard HYDRYER is a low-cost, packaged dehydration unit. It is ideally suited for use with precision instruments. The HYDRYER effectively removes moisture from air, carbon dioxide, synthesis gas and many other gases.

These exclusive design features make the HYDRYER superior to any other such unit on the market today:

- 100% of all air or gas entering is dried without loss.
- Full line pressure reactivation.
- Purging eliminated; HYDRYER uses inlet main air stream for reactivation.
- Longer adsorbent life; no movement due to pressure changes, high velocity.
- No moving parts . . . simplified design . . . . . plus many, many more!

*Registered Trade Name

GET THE ENTIRE HYDRYER* STORY!

Get all the facts. Send for Pritchard HYDRYER Bulletin No. 16.0.081 on your company letterhead. No charge or obligation.

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Kansas City 12, Missouri

COOLING TOWERS • GAS & AIR TREATING EQUIPMENT
REPRESENTATIVES IN PRINCIPAL CITIES FROM COAST TO COAST

For more information circle **60** on inquiry card.

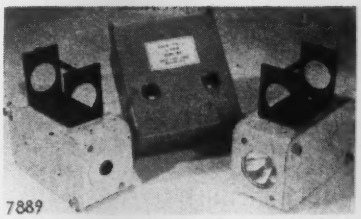
NEW INSTRUMENTS

alarm. Accessory is mounted in a non-hazardous location and draws a sample continuously through a copper line from a remote danger area. A high-quality pump (pictured inset) is optional. A flow meter and flow adjusting valve are included.—*Johnson-Williams, Inc., 2747 Park Blvd., Palo Alto, Calif.*

For more information circle **207** on inquiry card.

SMOKE ALARM

New "Smok-Trol 85" is an inexpensive non-indicating positive system for detection of smoke, used in



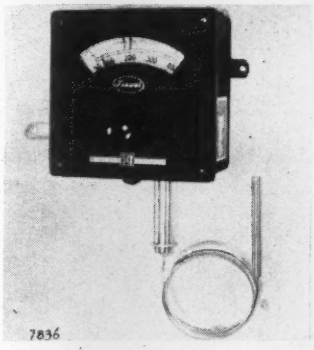
conjunction with audible or visual alarm systems; is of plug-in design for easy replacement of tubes, etc.; employs a cadmium sulphide cell for light detection.—*Smok-Trol Corp., 10 St. Pauls Pl., Ossining, N. Y.*

For more information circle **208** on inquiry card.

TEMPERATURE, HUMIDITY

TEMPERATURE CONTROLLERS

New "Series 541" indicating temperature controllers offer 2°F accuracy under optimum conditions; are

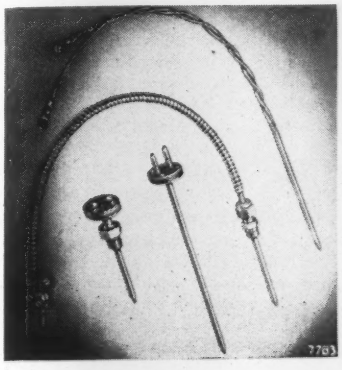


unusually convenient to adjust and service in the field. Interchangeable elements permit user to tailor control. Illustration shows a model with two control switches, each with a setpoint indicator, to actuate two separate circuits at preset temperatures.—*Fenwal Incorporated, Ashland, Mass.*

For more information circle **209** on inquiry card.

MINIATURE PROTECTED TCs

New miniature thermocouples with stainless steel protection tubes, for use in gases and liquids highly

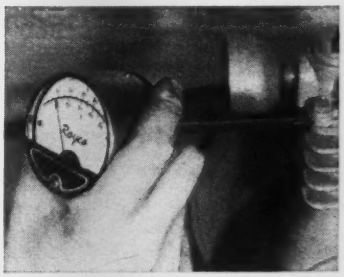


corrosive to TC materials, are well suited also to pilot plant and other limited-space applications; are available in I-C, C-C, and C-A, in ranges between limits of −300°F and 1600°F.—*Thermo Electric Co., Inc., Saddle Brook, N. J.*

For more information circle **210** on inquiry card.

SURFACE-TEMPERATURE INDICATOR

New "Pyro-Couple" is said to be capable of indicating surface temperatures on a 1-second contact. It



can also measure temperatures of liquids or solids such as granular materials.—*Royco Instruments, 819 Arthur St., Albany, Calif.*

For more information circle **211** on inquiry card.

TC WIRE INSULATION

New thermocouple wire insulation is said to offer greatly improved resistance to abrasion, solvent and acid resistance to 600°F; is suitable for continuous operation to 900°F in dry atmospheres. TC and lead wires utilizing new insulation and meeting MIL-W-5845, 5846 and 5908, are available in various gages.—*Revere Corp. of America, Wallingford, Conn.*

For more information circle **212** on inquiry card.

THERMISTORS

New precision thermistors cover a full range of temperature coefficients, resistances and current ratings; all

Endurance Rated
ELECTRIC COUNTERS
and ACTUATORS
to Fit every need

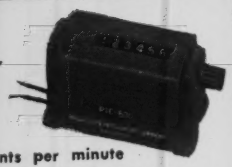
200,000,000 COUNT LIFE

PIC
SUPER-WIZARD

1000 CPM.
5 watts input.
Balanced Armatures.
4 and 6-digit models in basemount, panelmount and dustproof enclosed types for 60, 40-50, 25 cycles and DC; all voltages to 230.
Purchase cost only 18c per million counts.

50,000,000 COUNT LIFE

PIC
600



1000 counts per minute
7 watts power consumption
Balanced armature
Quiet operation. No AC hum.
Tamper proof housing.
Lubrication not required.
Available in basemount and panelmount models—also to count dozens, for 60, 40-50, 25 cycles and DC; all voltages to 150.

6,000,000 COUNT LIFE

PIC MERCURY
4-digit Reset

600 Counts per minute.
3 watts power input.
4-digit Basemount and Panelmount models also to count dozens — all voltages to 115, AC or DC.

3,000,000 COUNT LIFE

PIC MERCURY
5-digit non-reset

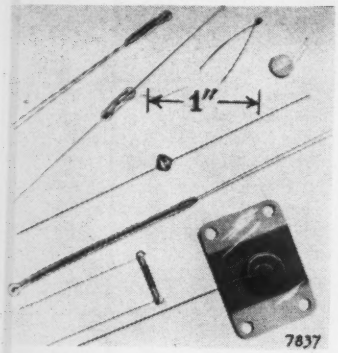
600 Counts per minute.
3 watts power input.
Tamper proof construction.

See your PIC Representative or write

PIC
PRODUCTION INSTRUMENT CO.
702 W. Jackson Chicago 6, Illinois

For more information circle **61** on inquiry card.

NEW INSTRUMENTS

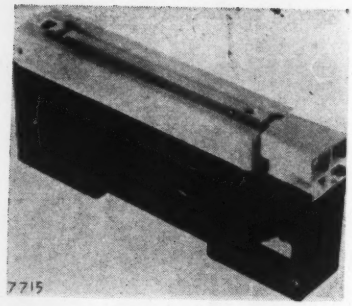


standard forms such as rods, discs, washers and glass-coated and uncoated beads.—*Fenwal Electronics, Mellon St., Framingham, Mass.*

For more information circle **213** on inquiry card.

ASPIRATION PSYCHROMETER

New "Psychron," originally designed for use by U. S. Weather Bureau, will be useful in industrial



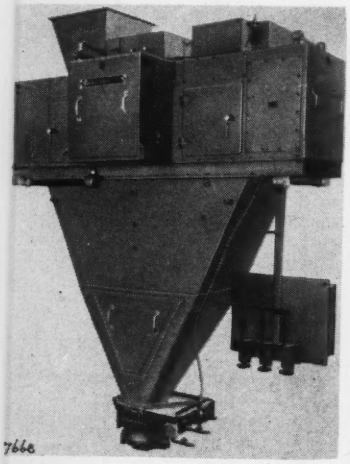
fields; is 10" long and weighs 2½ lbs; comprises a matched wet- and dry-bulb thermometer assembly ventilated by a tiny fan driven by a flashlight-battery-powered motor. Thermometers are accurate to 0.3 Fahrenheit degree at any point. Temperature range 10-100°F; relative humidity range 10-100%. Built-in thermometer illumination system makes for easy reading in the dark. Accessories include special slide rule.—*Bendix Aviation Corp., Friez Instrument Div., 95 First St., Teterboro, N. J.*

For more information circle **214** on inquiry card.

FORCE, LOAD, WEIGHT

AUTOMATIC BAGGING SCALE

New "Weighblender" proportions and bags ten or more sacks of dry aggregate ingredients per minute with

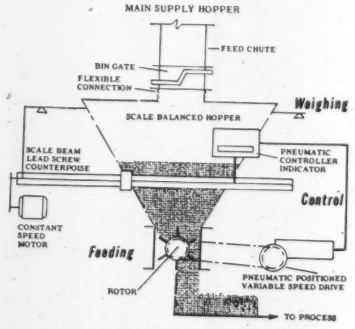


individual accuracies of 1 to 2 oz (or better) when handling bags of 25 to 100 lb.—*Richardson Scale Co., Van Houten Ave., Clifton, N. J.*

For more information circle **215** on inquiry card.

GRAVIMETRIC FEEDERS

New continuous "Loss-in-Weight Feeders" feed solids at rates up to 40,000 lbs/hr with accuracy of 0.5% of set feed rate. Two basic types: (1) "Simplex Model 30A" (shown) has a single material hopper containing several hours' supply of material, lead screw rotated at constant speed



to position counterpoise along scale beam at a rate corresponding to desired feed rate; pneumatic controller commands feeding mechanism to insure uniform feed. (2) "Duplex Model 30" features two hoppers: one feeds while the other is being filled; automatic reversal of feeding-filling cycle.—*Omega Machine Co., 345 Harris Ave., Providence 1, R. I.*

For more information circle **216** on inquiry card.

FORCE TRANSMITTERS

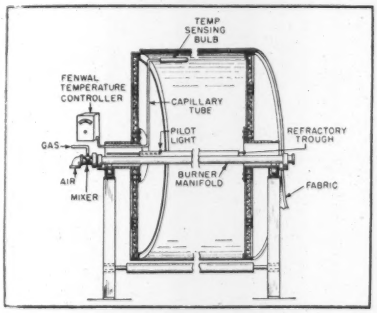
New "SR-4 Universal-type Load Cells" of 50-, 100-, and 200-lb capacity have been reduced substantially

Controlling A Radiant-Heat Drying Drum

No. 3 in a series — *Showing the Broad Application Range of Fenwal Controls*

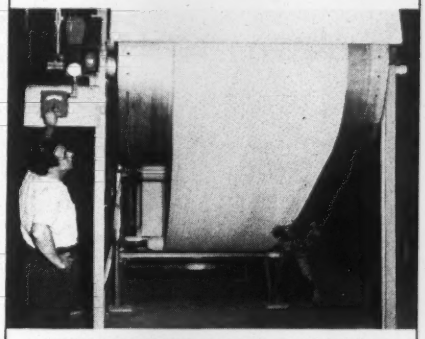
This high-temperature, radiant-heated drying drum is used for drying printed fabrics or for heat-setting synthetic coatings onto fabrics. Particularly interesting is the way in which it combines a Fenwal unit and quick cooling features to secure the close temperature control necessary to prevent scorching the fabric in case of shut-downs.

The drum is usually operated at a surface temperature of 350° to 450°F, but can maintain temperatures up to 700°F, as required. The revolving drum surface is heated by a combination of infra-red rays and convection from a refractory trough heated to incandescence (about 2400°F) by a gas-air manifold burner.

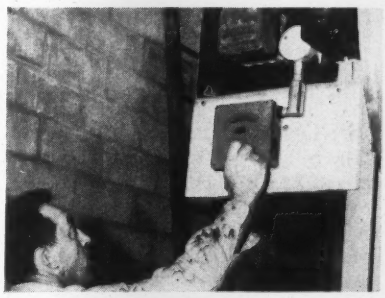


Drum temperature is controlled by a Fenwal Series 540 Indicating Temperature Controller. As shown in the diagram, this is connected by a capillary tube to the temperature-sensing bulb, located close to the interior surface of the drum. The trough and manifold are stationary along the axis of the drum. Flame is played along the surface of the trough by a series of jet nozzles, burning a mixture of air and natural or manufactured gas. To aid in preventing scorching the product, materials used for the drum and heater system are of lowest practical heat capacity. The drum surface is of 16-gauge steel, which assures a low heat content.

Also, the combustion air supply doubles as a coolant for the drum. The air stream is not tied in with the temperature control system and continues to flow after the gas is shut off. Thus, it quickly cools the heater trough and blows the heated air out of the drum. This, plus the low heat capacity of the drum surface, provides the required safeguard against scorching the product during sudden shut-downs.



PRECISE TEMPERATURE CONTROL, provided by a Fenwal Series 540 Temperature Indicating Controller (shown at left) is one of the advantages enabling this huge drying drum to set new records for efficiency. In one installation, three 60" diameter drums of this type are drying the same yardage as 20 previously used steam-dryers.

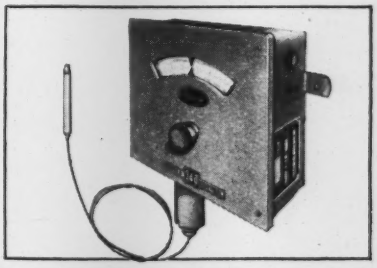


Control Within ¼ of 1%

When the operator sets this Fenwal Series 540 Controller to the required processing temperature, he knows that temperature will be maintained — on the button! Heat input is controlled by the Fenwal unit, actuating a solenoid valve in the supply line. The gas, maintained at atmospheric pressure by a diaphragm regulator, is drawn into a proportioning mixer valve under negative pressure created by the air stream. The air supply, maintained at approximately one psi, reaches the mixer through a separate supply line.

With the Series 540 Control on guard over the heating system, the manufacturer of this advanced drying equipment states that the temperature of the drum surface is maintained within ± one-quarter per cent of the controller scale — outstanding performance for processing equipment of this type.

A Versatile Instrument



The Series 540 Controller is fully adjustable between 100°F and 700°F. Temperature differential is adjustable between 1% and 4% of scale temperature ranges by internal adjustment of pilot contacts. Uniform sensitivity and close accuracy throughout its range are characteristic, making it an ideal temperature indicating controller for kilns, ovens, liquid baths, baking ovens, packaging machinery and general industrial processing.

For Your Own Applications

Investigate the many different types of Fenwal temperature control and detection devices. Besides the Series 540 described here, these include standard THERMOSWITCH® units, Midgets, Miniatures, etc. Send the coupon for new Catalog No. 500. Remember that Fenwal's engineering staff is always ready to help you solve any temperature control problem.

FENWAL INCORPORATED
369 Pleasant Street
Ashland, Mass.

Please send me your Catalog No. 500. Our specific problem is:.....

.....

.....

Name.....*Title*.....

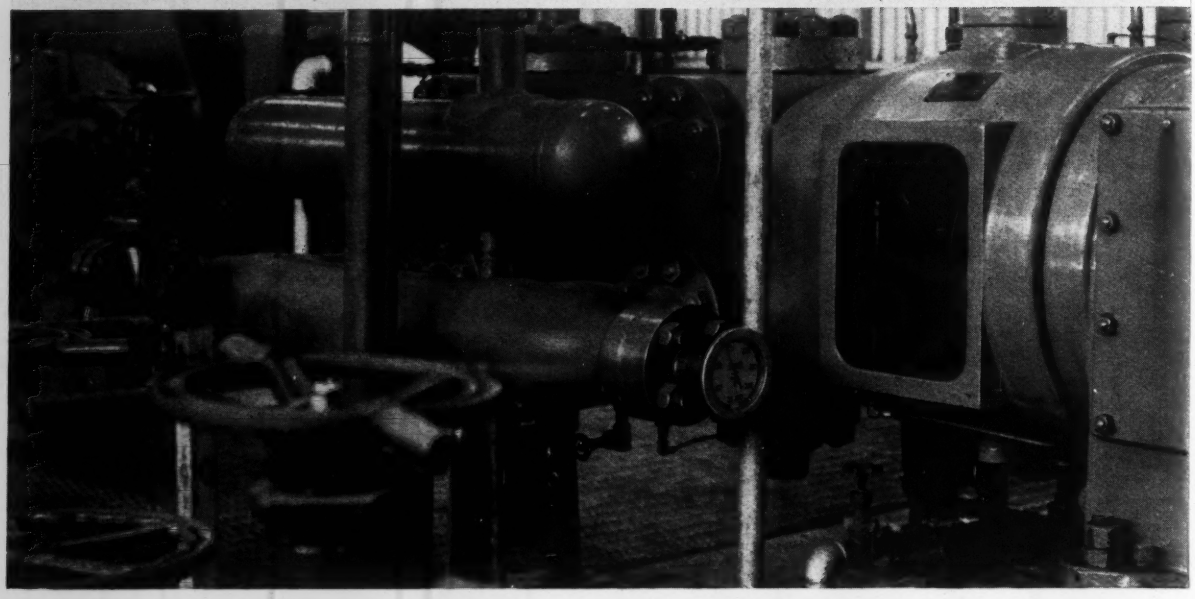
Address.....

City.....*Zone*...*State*.....

Fenwal CONTROLS TEMPERATURES . . . *PRECISELY*

For more information circle **62** on inquiry card.

VIBRATION

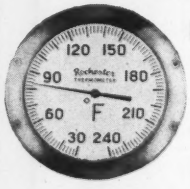


Vibration of refinery compressor proves unshakable accuracy of RMC thermometer

The RMC Thermometer shown in the photograph is constantly subjected to extreme vibration from the two-stage Synthesis Gas Compressor on which it is installed. This powerful equipment is used to compress a mixture of H_2 and N_2 from 400 to 3500 pounds—at the Philadelphia Synthetic Ammonia Plant of The Atlantic Refining Company.

This particular job required a special thermometer that could withstand the constant and terrific vibration, and at the same time provide and maintain precise, accurate readings. Rochester Manufacturing Company promptly came up with the answer—a silicone-dampened, bimetallic, angle-form RMC thermometer. And this is but one example of how RMC engineering skill provides instruments that meet the most demanding and exacting requirements.

Look to RMC for Full-Line Instrumentation



DIAL THERMOMETERS

Illustrated here is a 6" dial thermometer with hermetically sealed dial chamber, external recalibration—built for heavy duty service. What are your thermometer requirements?

PRESSURE SWITCHES

This RMC Pressure Switch will stand heavy pulsating pressures, has close on-off differentials, maintains consistent cut-in, cut-out settings. What are your pressure switch problems?

TELL US YOUR REQUIREMENTS FOR DIRECT MOUNTING AND REMOTE INDICATING INSTRUMENTS, AND LET RMC ENGINEERING SKILL PROVIDE THE ANSWERS!

REPRESENTATIVES IN ALL PRINCIPAL CITIES

RMC

"You Can Rely On Rochester"

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

ROCHESTER MANUFACTURING CO., INC.

139 ROCKWOOD STREET • ROCHESTER 10, N.Y.

© 1956 Rochester Manufacturing Co., Inc.

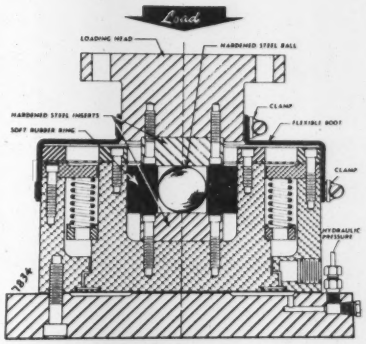
For more information circle 64 on inquiry card.

in size and designed with linearity (within plus or minus 0.1%) improved 100% over previous models.—*Baldwin-Lima-Hamilton Corp., Electronics and Instrumentation Div., 806 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **217** on inquiry card.

TANK AND HOPPER WEIGHING SYSTEM

New load cell features off-center loading stability for bin, tank and hopper weighing systems by means of unique rolling-ball construction. A hardened steel ball beneath loading platform, between two hardened steel inserts, not only permits tank or bin to expand laterally but correctly



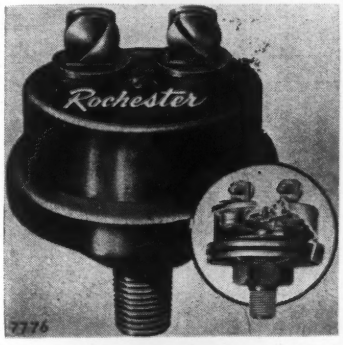
transmits force, which is then converted into hydraulic pressure to actuate an indicator, recorder or controller.—*The A. H. Emery Co., New Canaan, Conn.*

For more information circle **218** on inquiry card.

PRESSURE, VACUUM

VACUUM SWITCH

New heavy-duty vacuum switch, housed in a hermetically-sealed steel case, features a spring-loaded Buna-

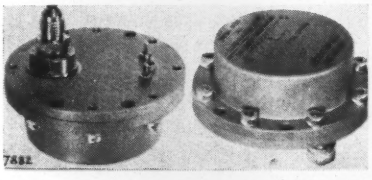


N-impregnated diaphragm protected against heavy vibration, pulsation and shock; is available for N-O or N-C use at zero vacuum with settings up to 22".—*Rochester Mfg. Co., Rochester 10, N. Y.*

For more information circle **219** on inquiry card.

PRESSURE PICKUPS

New pressure pickups of variable-resistance type are said to have been developed for use "in conjunction

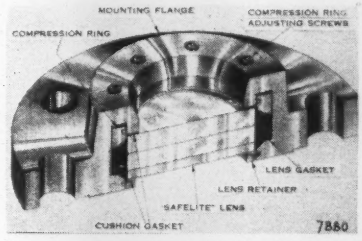


with satellite and missile telemetering problems wherein temperatures up to 500°F and corrosive fluid and gas pressures up to 1500 psi will be encountered."—*Rahm Instruments, Inc., 12 W. Broadway, New York 7, N. Y.*

For more information circle **220** on inquiry card.

PRESSURE-SAFE LENS

New lens and mounting combination is said to be "the solution to sight glass problems in pressure vessels."



Device is equipped with "Safelite" lens, consisting of two pressure discs and one shielding disc, positioned in a flanged body, with non-extrudable top-and-bottom cushion gaskets. This in turn is surrounded by packing which eliminates undue stress on glass and risks taken when flange bolts are tightened.—*PresSure Products Co., P. O. Box 424, Charleston 22, W. Va.*

For more information circle **221** on inquiry card.

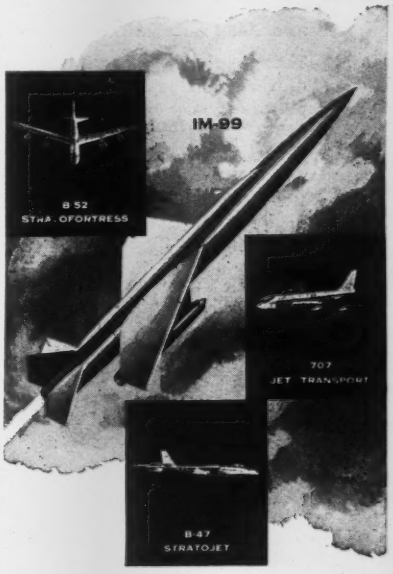
SINGLE-SCALE VACUUM GAGE

New thermocouple-type vacuum gage, with a range of 0-100 microns Hg full-scale, has a 4" indicator with

Do you think about Angular Acceleration?

BOEING does

...and uses Statham Angular Accelerometers to test...

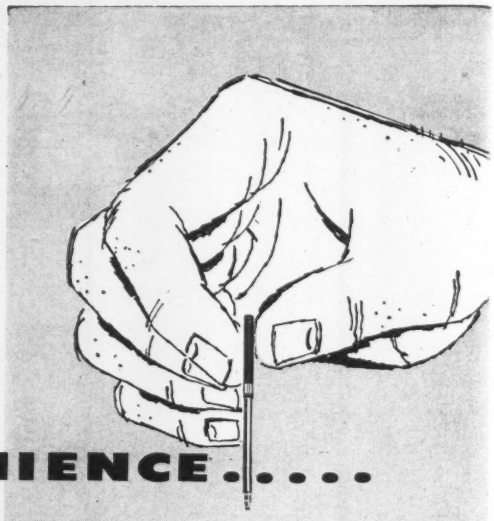


Statham unbonded strain gage liquid rotor angular accelerometers offer a simple, reliable means for the study of the rotary motion of a test body under conditions where a fixed mechanical reference is not available. For static and dynamic measurements in ranges from ±1.5 to ±3,000 rad/sec², four standard models are offered.

Please request Bulletin AA2

Statham
LABORATORIES
LOS ANGELES 64, CALIFORNIA

For more information circle **65** on inquiry card.



MORE

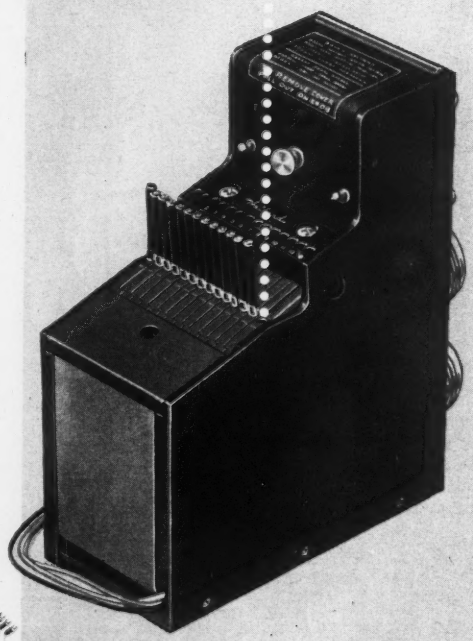
CHANNELS.....
OPERATING CONVENIENCE.....

WITH HEILAND SERIES 700 RECORDING OSCILLOGRAPHS

The new Heiland magnet assembly with its subminiature galvanometers for use with the New Series 700-C Oscillograph gives you more channels, broader frequency range, and higher sensitivities throughout a wider temperature range for your most complex recording requirements.

The new sub-miniature galvanometers sit side by side in a minimum of width, making it possible for the Model 712-C Oscillograph to put as many as 60 simultaneous traces on a 12-inch record. The 708-C carries up to 36 channels on an 8 inch record. The galvanometers and damping resistor networks are easily accessible from the front of the oscillograph through a hinged cover door. Galvanometers with a broad range of sensitivities are available in frequencies up to 5000 CPS. The lower frequency galvanometers require as little as 4 microamperes per inch of deflection.

Both the 708-C and 712-C Models feature record speeds from .03"/sec. through 144"/sec.



Heiland 700-C Recording Oscillographs will expand the scope of your dynamic recording. For complete details, write for Bulletin No. 700-CB2.

Heiland® H HONEYWELL
A DIVISION OF MINNEAPOLIS-HONEYWELL
5200 E. Evans, Denver 22, Colo.

For more information circle 66 on inquiry card.

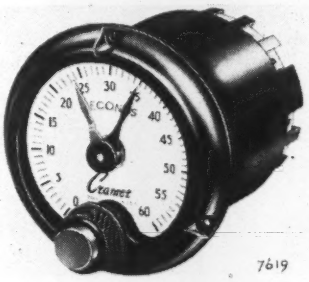
knife-edge pointer for direct reading on a logarithmic mirror scale. Half-scale is 15 microns, providing excellent readability for low-micron measurements. Improved design of gage tube, incorporating maker's temperature-compensated noble-metal thermopile, provides greater sensitivity and higher accuracy in low-micron range; is not damaged by release to atmospheric or positive pressures; need not be removed during cleaning of vacuum system.—*Hastings-Raydist, Inc., Hampton, Va.*

For more information circle **222** on inquiry card.

TIME, SPEED, COUNT

AUTOMATIC-RESET TIMERS

New "Type 241" automatic-reset type interval timers for industrial, process control and lab use are avail-



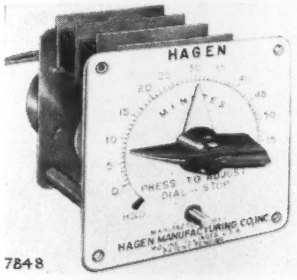
7619

able in full-scale ranges from 15 sec to 24 hr; feature 0.25% repeat accuracy, a completely new drive, and automatic reset mechanism actuated by maker's high-torque synchronous motor.—*Cramer Controls Corp., Centerbrook, Conn.*

For more information circle **223** on inquiry card.

MULTI-CIRCUIT TIMER

New "Model 73" multiple-circuit single-interval timer is designed for low-cost application where a process



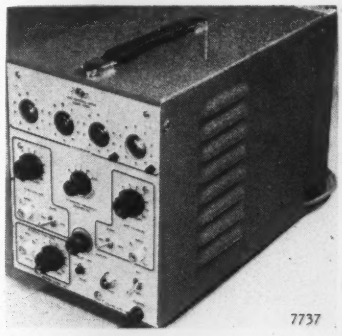
7848

is to be turned on manually, run for a preselected time, and stopped automatically. Standard models are available with one to ten circuits and time ranges from 15 sec to 1 hr. Contacts rated 15 amp 115 vac.—*Hagen Mfg. Co., Inc., Moline, Illinois.*

For more information circle **224** on inquiry card.

TIME AND SPEED COUNTER

New "Model 7440A Time Interval Meter" uses cold-cathode glow transfer tubes for measurement of time intervals, periods, and velocity. Electrical impulses define interval to be measured to start and stop a gate. In-



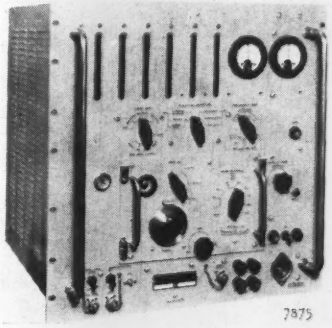
7737

strument counts number of cycles of crystal-controlled frequency occurring during this gate. Indication is directly in milliseconds to 9,999. Automatic recycling, or measurement held for manual reset. Available with print-out.—*Electro-Pulse, Inc.,* 11861 *Teale St., Culver City, Calif.*

For more information circle **225** on inquiry card.

FREQUENCY COUNTER

New "No. 14-20-FM Electronic Counter" is a commercial version of Military Type AN/USM-26. It dis-



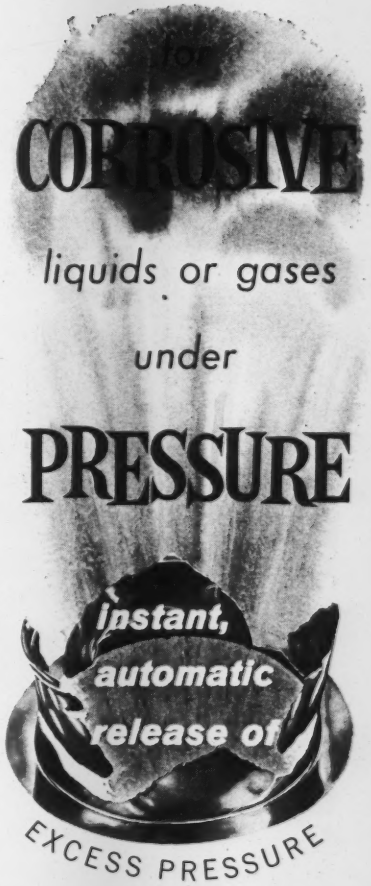
7875

plays measured frequency automatically in digital form. Frequencies measured can be periodic or random: 10 cps to 220 Mc. In addition, counter can be used to measure time intervals, pulse lengths, rep. rates, frequency drift, events, etc.—*Northeastern Engineering, Inc., Manchester, N. H.*

For more information circle **226** on inquiry card.

PROXIMITY PICKUP

New "Midget Impulse Generator," smaller companion to "Model 50-A," likewise provides self-generated output frequency proportional to speed of ferromagnetic material passing its



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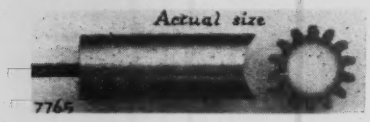
For more information circle **67** on inquiry card.

NEW INSTRUMENTS

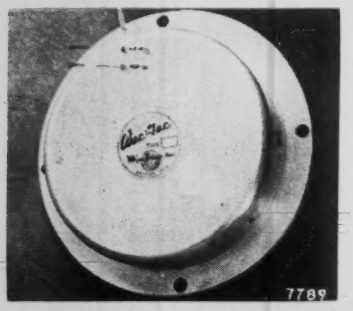


sensitive end; will stand operating temperatures to 500°F; can be had with sensitive end contoured.—*Minatron Corp., 3 Cliveden Place, Belle Mead 3, N. J.*

For more information circle **227** on inquiry card.

MACHINERY TAC GENERATOR

New "Model 5 Wac-Tac," for mounting within frame of integral-hp motors and automatic machinery (or for external attachment), features "pancake" design with minimal protrusion; delivers an alternating voltage whose frequency and magnitude

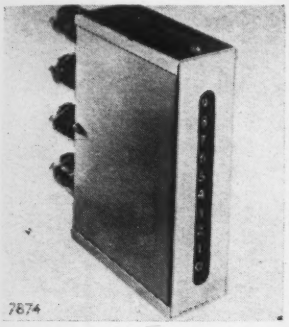


are linear with speed: as high as 25 v per 100 rpm and 30 cps per 100 rpm. No slip-rings, brushes, or contacts.—*WacLine, Inc., 35 S. St. Clair St., Dayton 2, Ohio.*

For more information circle **228** on inquiry card.

PLUG-IN DECADE COUNTER

New "Models 140-40 and 140-100" display count of electrical pulses by a neon light illuminating appropriate

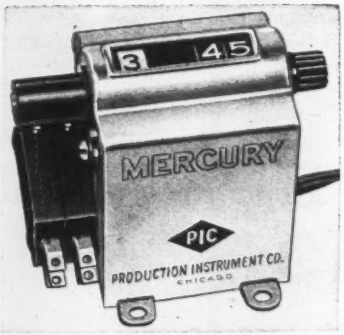


digit of count. They recycle automatically after every ten counts but display remainder "answer" count until reset. Model "140-100" has a maximum counting rate of 100 kc and Model "140-40" 40 kc.—*Northeastern Engineering, Inc., Manchester, N. H.*

For more information circle **229** on inquiry card.

BATCH COUNTER

New improved small electric batch counter is easily preset to count any quantity to 900 and operate an elec-



tric switch. Developed primarily for vending equipment, it is suitable for light duty industrial service.—*Production Instrument Co., 702 W. Jackson Blvd., Chicago 6, Ill.*

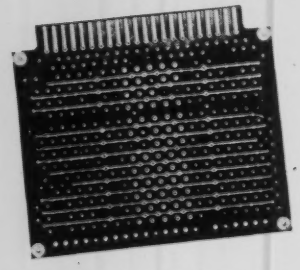
For more information circle **230** on inquiry card.

WORK-LOAD CYCLE COUNTER

New "Telemetering Load Cycle Counter" counts only work or operations actually performed. It differentiates between idling, dry-run and load cycle; counts only load cycle by sensing current flow to electrically-driven machines such as presses, or

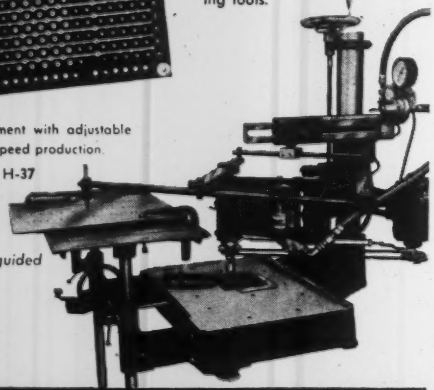
TRACER-GUIDED DRILLING
100 HOLES P. M.
WITH NEW HERMES Engravograph

for printed circuit plates



• Pantograph reproduces drill pattern from template in any reduction ratio — assuring high accuracy.

• Allows drilling and routing of different size holes in one operation without changing tools.



Pneumatic attachment with adjustable feed gives high speed production.

Ask for catalog H-37

Also for tracer-guided
ENGRAVING
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THE RIGHT GAUGE
FOR YOUR
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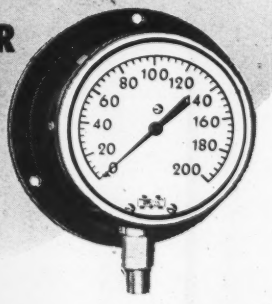

- PRESSURE
- VACUUM
- COMPOUND
- ALTITUDE
- COMBINATION
- DIAPHRAGM
- HYDRAULIC
- AND SPECIAL PURPOSE GAUGES
- DIAL THERMOMETERS (Vapor Tension or Bi-Metal)

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Marshalltown 3, Iowa

For more information circle **68** on inquiry card.

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
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DRIFT FREE
DC μv
AMPLIFIER

MODEL 111

The **KAY LAB MODEL 111** amplifier provides the lowest drift of any commercially available broadband d-c amplifier. The unique circuit incorporates **KAY LAB's** proven chopper amplifier system to provide unsurpassed dynamic performance — unaffected by load or gain changes. Available in a single-unit cabinet or a six-amplifier rack-mountable module only 19 inches wide, the **Model 111** is ideal for data reduction facilities, or as a strain gage amplifier, recorder driver amplifier, or general purpose laboratory amplifier.

SPECIFICATIONS

- ± 2 uv equivalent input drift
- Integral power supply
- ± 35V, ± 40 ma output
- 100,000 Ω input impedance
- 0 to 1000 gain in ten steps
- ± 1% gain accuracy
- 5 uv peak equivalent input noise
- Price (Single) Amplifier $550.00

Representatives in All Major Cities

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For more information circle **70** on inquiry card.

NEW INSTRUMENTS

welding and other electrically-powered operations. It can be used also as a warning and/or counting instrument for dull tools, etc. Telemetering feature permits simultaneous counting at machine and control center. Mechanism is sealed in a dust-proof, tamper-proof locked box.—*Ram Meter, Inc.*, 1100 *Hilton Road, Ferndale, Detroit* 20, *Mich.*

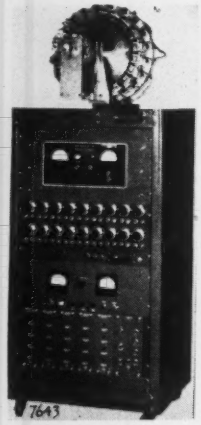
For more information circle **231** on inquiry card.

Tell Your Friends Too:

You can get a practical course in automation (including office automation, process automation, plant automation, analog computing, digital computing, and/or data handling) for only $10 at the Third International Automation Exposition, New York, Nov. 26-30, 1956. For details see pages 1756-57.

COMPUTING and DATA PROCESSING

SEISMIC TIME DOMAIN FILTER SYSTEM



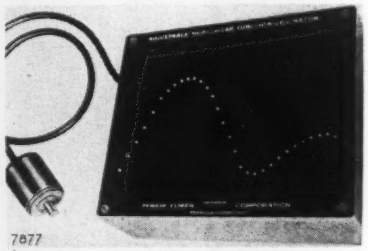
7643

New "Magne-Filter" for linear or non-linear filtering of noise from broad-band energy, particularly useful in seismic exploration, is a specialized analog computer using cross-correlation technique. Trace to be filtered is compared at each instant of time against a filter transient which has been computed from the amplitude and phase conditions desired of a particular filter. Sum of products of samples from both trace and transsient at any instant thus becomes a running correlation between the two. A wide variety of filters can be simulated, obviating actual construction of filters.—*Houston Technical Labs., P.O. Box* 6027, 2424 *Branard, Houston* 6, *Texas.*

For more information circle **232** on inquiry card.

FUNCTION GENERATOR

New "Non-Linear Function Generator" is a new type of device, which will relate any non-linear function to a shaft rotation. It is said to be easily and quickly adjustable to provide any mathematical or empirical function including those with multiple slope reversals. Applications include non-linear servo field, computers, and series or a least squares fit (orthogonal polynomial); will also produce a slope equation or an integral equation of the curve; will perform a twelve-term Fourier analysis or a fourth-power fit in less than ten minutes.—*Gerber Scientific Instrument Co.*, 162 *State St., Hartford* 1, *Conn.*



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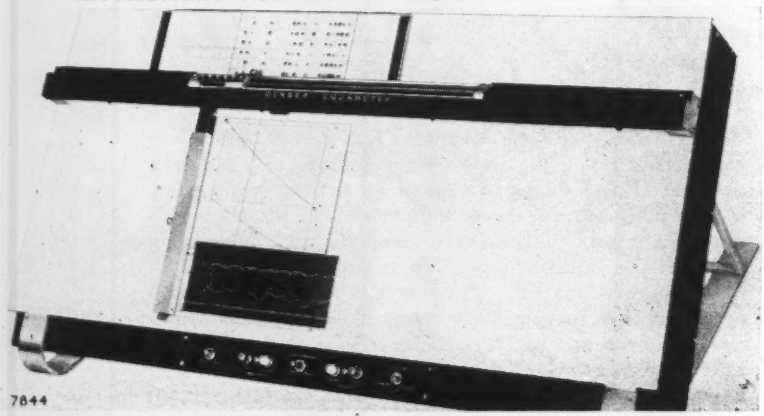
INSTRUMENT FOR FINDING EQUATION FOR CURVES



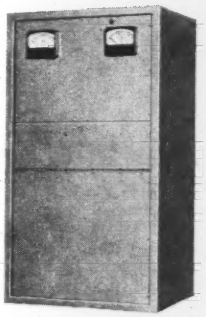
7844

New "Model GEQ-400 Equameter" electrically-driven analog computer performs harmonic analysis and curve-fitting on plotted or recorded curves; yields reproducible results in hands of operators with little math background; analyzes a curve in terms of a Fourier series, a power

For more information circle **233** on inquiry card.

magnetic research corp.

a complete line of ALL-MAGNETIC COMPONENTS and MAGNETICALLY REGULATED POWER SUPPLIES



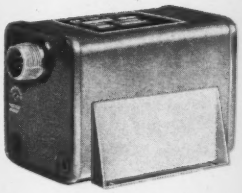
STABLVOLT* DC COMPUTER POWER SUPPLY

Dual magnetic regulation—line transient-free

Stablvolt d.c. power supply provides line transient-free, precision-regulated d.c. output voltage, meeting the strict requirements for analog and digital computer applications. Flux oscillator controlled. Very low ripple, excellent dynamic and static regulation. Extremely low internal impedance. Maintenance-free. Ultra-fast response. Short-circuit proof. Available in a wide range of voltage and current levels.

Write for complete data.

TUBELESS PRECISION MISSILE AND AIRCRAFT INSTRUMENT POWER SOURCE MRP-5-1S

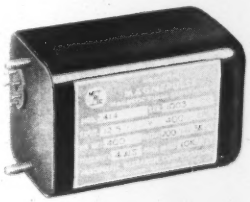


5 VDC transient-free output

Dual magnetic system isolates line voltage transients from the output, regulates d.c. to 0.1% accuracy. Does not distort line voltage wave form. Use of 2306-55 Cannon connector permits unit to carry 115 VAC up to 60,000 feet. A 25-turn Trimpot has 5 millivolt resolution, provides 0.5 volt output adjustment. Mounts easily in any position. Rugged, compact, short circuit-proof. Current capacity, 1 amp. Vibration tested with 15g up to 2,000 cps. Hermetically sealed; all components cast in thermosetting plastic. Meets MIL-T-27 and MIL-E-5272-A specs.

For full data, request Engineering Bulletin EB-5-1

ALL-MAGNETIC AIRBORNE PULSE GENERATOR MP 414

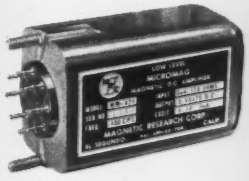


For commercial radar and digital computer uses

Uses only 1 watt of power, provides 250V pulse into 500 ohms. Pulse width: 4.5 microseconds; repetition rate: 400 pps. Weighs only 14 ounces, is hermetically sealed, and operates on 115V-400 cycle supply. No tubes, no moving parts. Short circuit-proof. Units available in ranges from 1 to 10 megawatts to replace conventional hydrogen thyratron pulse modulators in radar systems.

For full data, request Engineering Bulletin EB-204

MICROMAG* LOW-LEVEL MAGNETIC DC SIGNAL AMPLIFIER

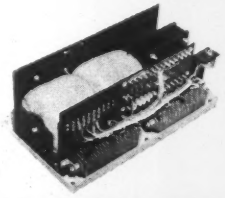


Drift-free—for thermocouple and strain gauge applications in telemetering systems

Provides ripple-free 5 VDC output from 1 millivolt d.c. input, with extremely high gain stability. Response time: 40 milliseconds. No pick-up—no shielding required. No tubes, no warm-up time. Withstands extreme vibration and shock without introducing spurious noise. Reliable in high environmental temperatures. Operates on 400 cycles. Also useful for temperature and strain measurements in industrial and medical work. Weighs less than 7 oz.

For full data, request Engineering Bulletin EB-201-A

HIGH-POWER INDUSTRIAL MAGNETIC SERVO AMPLIFIERS



For servo systems in automatic control

Operate on standard commercial 50-to-60 cps power. Amplifiers are entirely static with power outputs from 0.1 to 5 kw. Compact, rugged units provide maintenance-free, reversible a.c. or d.c. control for high-power a.c. or d.c. servo motors. Transistor or tube control. These single and two-stage magnetic amplifier units require less than 1 watt of control signal power. Response time: Less than 25 milliseconds. Long life, low cost. ***Write for complete data.***

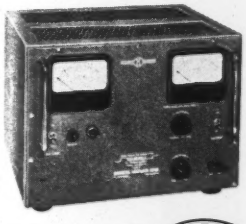
INSTRUMENT MAGNETIC SERVO AMPLIFIER SERIES

For aircraft and missile servo systems

Precisely engineered Magnestat Magnetic Servo Amplifiers are available from stock, from the smallest model rated at 3 watts, and having a frequency response of 0-30 cps, to the high-power 40-watt model, frequency 0-10 cps. These units have sinusoidal phase reversing output, with transistor or tube control . . . a.c. or d.c. input. Currently being applied in many major aircraft and missile servo systems.

For complete data, request Magnestat Series engineering bulletins.*

DC LABORATORY STABLVOLT POWER SUPPLY MR 532-15



Line transient-free—

ideal for transistor work

Highly versatile, filtered d.c. lab power supply offers continuous, precise regulation from 3 to 36 VDC at 15 amps. Dual magnetic circuitry isolates line voltage transients from the output. Short circuit-proof, maintenance-free. No tubes, no moving parts. Excellent static and dynamic regulation. Has vernier d.c. voltage adjustment control. Uses flux oscillator type AC line voltage regulator. Has many uses in the laboratory, in original equipment and in industrial quality control. Competitively priced.

Write for complete data.

FOR YOUR SPECIAL DEVELOPMENT NEEDS . . .

MRC offers a complete service in creative engineering, design, development and production. Whatever your field of application—automation, computer, communication, electronic, instrumentation, aviation or guided missile—you'll find that MRC men have the highly specialized magnetronic experience and skill to do a fast, successful job. If you have a special problem involving magnetronic components, write or call MRC. Prompt response, no obligation.

*REG. TRADE MARK

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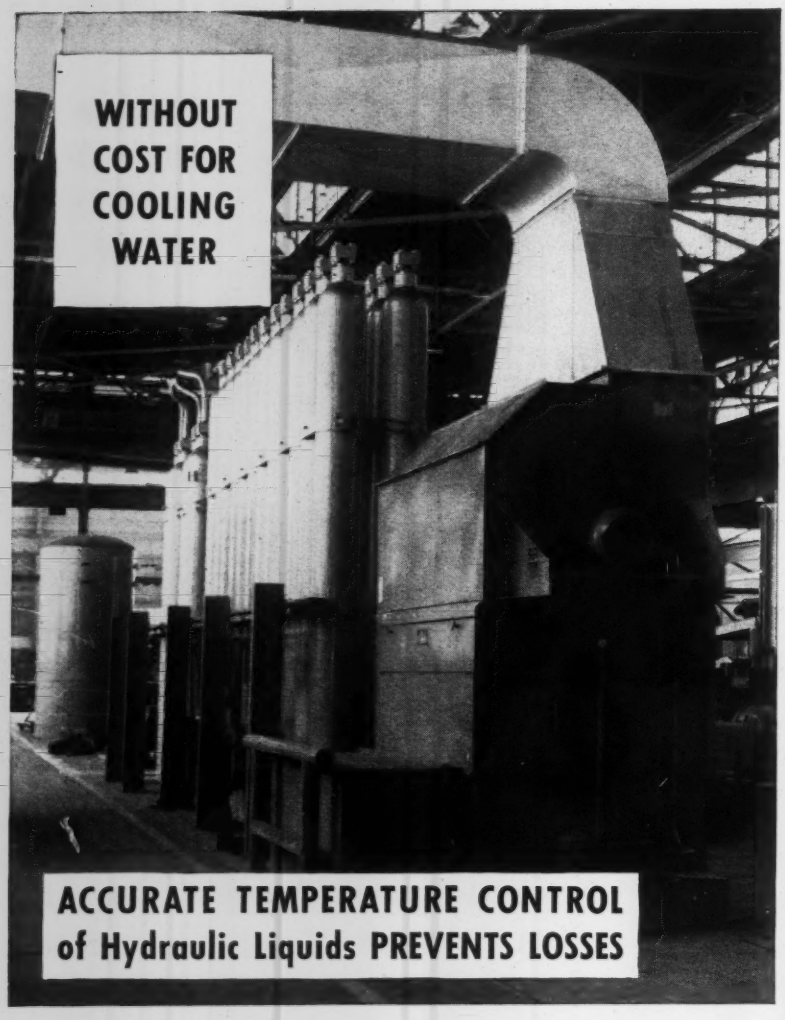
For more information circle **71** on inquiry card.



ACCURATE TEMPERATURE CONTROL of Hydraulic Liquids PREVENTS LOSSES

● This NIAGARA AERO HEAT EXCHANGER cools the liquid for a large hydraulic press, preventing heat damage to the pump stuffing boxes. Using outdoor air as the evaporative cooling medium, it removes the heat at the rate of input (1,875,000 BTU/hr.) with no cooling water consumption except a negligible amount evaporated.

Air is free and cheaper to move than water. You can save much expense in pumping, piping and power, and quickly recover the equipment cost from the water saving.

Similar Niagara machines cool water, oils, solutions, lubricants and coolants for many mechanical, electrical and chemical processes. You can cool quench baths, welding machines, plastic molds, furnaces, controlled atmospheres, gases, compressed air either for power or instruments or processes. In a closed system, your coolant is never contaminated. The system is simple and easy to keep up; the equipment has a long, useful life. Select from a wide range of sizes up to 30,000,000 BTU.

Write for Bulletin 120 to obtain a complete description.

NIAGARA BLOWER COMPANY

Dept. IN, 405 Lexington Ave. New York 17, N. Y.

Niagara District Engineers in Principal Cities of United States and Canada

For more information circle **72** on inquiry card.

correction of non-linear primary measuring elements. Available for use at nominal frequencies of 60 and 400 cps at input voltages up to 130. Use at lower frequencies is possible by proportionate reduction of input voltage. Special transformers can be provided when necessary for use up to 10,000 cps. Maximum output impedance is 130 ohms regardless of slope adjustment.—*Perkin-Elmer Corp., Norwalk, Conn.*

For more information circle **234** on inquiry card.

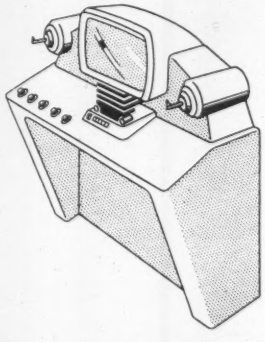
ELECTRONIC COMPUTER

New "ALWAC 800 Series electronic data processing system is said to have speed, storage capacity, and versatility "at least equal to million-dollar computing systems" though priced about one-eighth of that amount. Using 12 decimal digit numbers, it is capable of 11,000 additions, 2,000 multiplications, or 13,000 comparisons per second. Its high-speed internal memory can be supplemented with up to 10 magnetic drum storage units, each having a 12 million decimal digit capacity, and a 4 millisecond access time. Multiple tape units provide greatly enlarged additional lower speed storage. Input-output consists of punched cards, line printer, high-speed paper tape, and electric typewriter, as required.—*Logistics Research, Inc., Redondo Beach, Calif.*

For more information circle **235** on inquiry card.

FILM-DATA PROJECTOR

New "V-500" projects film-recorded data onto a self-contained viewing screen for study and evaluation. A



single frame image can be held, or film can be run at variable speed, forward or reverse. Interchangeable film transports take film sizes from 8 to 70 mm. Image can be rotated 360° on 21x21" viewing screen.—*Richardson Camera Co., 171 West Magnolia, Burbank, Calif.*

For more information circle **236** on inquiry card.

AN-DIG CONVERTERS

New Analog-to-Digital Converters are available in a complete range of counts up to 543,288; are conserva-

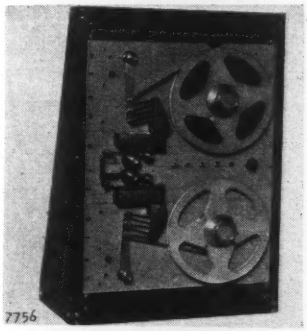
7873

tively rated at better than 500 million counts at 200 rpm before cleaning is required. Features: number and complement available simultaneously, rapid readout, increasing count available in either direction, low torque and inertia, easy reading while shaft is in motion, dc or pulse input, unambiguous natural binary output, parallel readout.—*Norden-Ketay Corp., 99 Park Ave., New York, N. Y.*

For more information circle **237** on inquiry card.

TAPE HANDLER

New "Model 101" digital magnetic tape handler features magnetic amplifier reel servos to provide improved



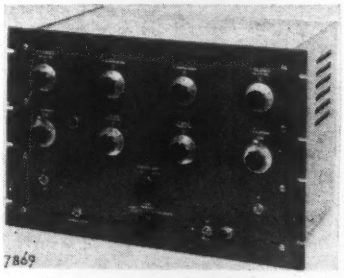
7756

dependability, greater power output, and smaller size than the electronic amplifiers they replace; start-stop time less than 5 ms; complete remote control of start, stop, reverse, and speed change.—*Key Electric Corp., 287 Post Ave., Westbury, N. Y.*

For more information circle **238** on inquiry card.

TAPE TRANSLATOR

New "Model 50 Tape Translator" enables automatic plotting of digital information from perforated paper tape when used in conjunction with a standard tape reader and an "Autograf Model 2 X-Y Recorder." It is adaptable for use with computers and a variety of perforated tape prepared on a Flexowriter, IBM tape punch, or other similar equipment. Standard machine will accept any 1-



7869

SIEMENS
MEASURING INSTRUMENTS

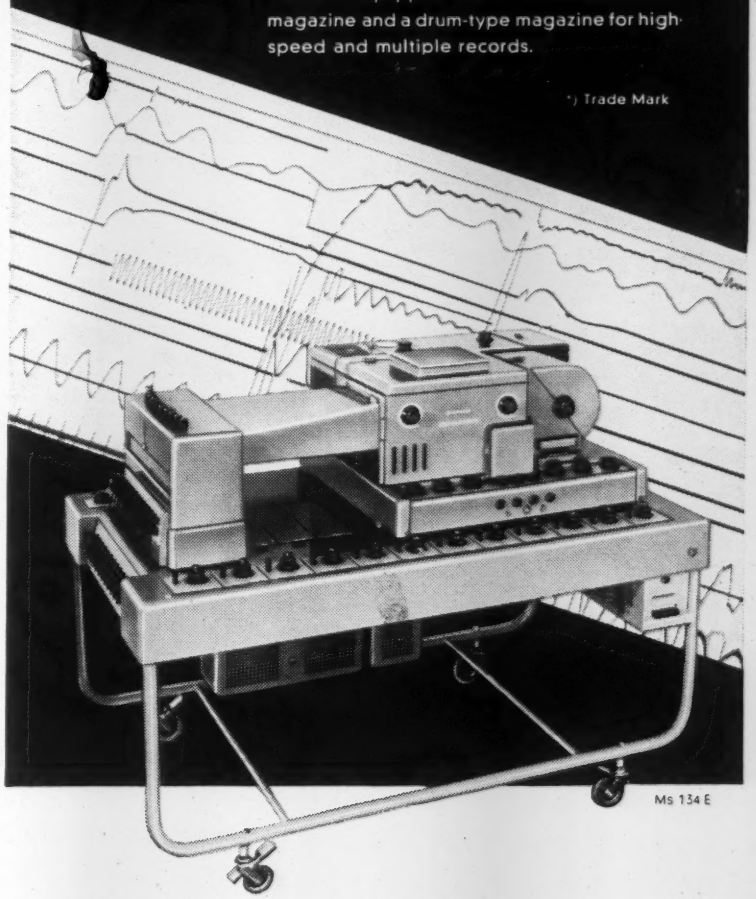
Outstanding Performance

in recording numerous electrical and mechanical quantities as a function of time is the design feature of the High-duty Multi-element Recording Oscillograph

OSCILLOGRAND *)

which is equipped with a continuous-drive magazine and a drum-type magazine for high-speed and multiple records.

*) Trade Mark



Ms 134 E

Automatic feeding and triggering

Complete facilities for remote control, triggering the oscillograph by the phenomenon, controlling the phenomenon by the equipment, etc.

Paper drive: D.C. motor and synchronous motor.

Continuously variable paper speed: 0.025 up to 8.2 ft./sec and 0.1 up to 33 ft./sec.

Linear frequency response of vibrators up to 6,000 cps.

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For more information circle **73** on inquiry card.

2-4-8 binary code and (on special order) any other code. Command codes can be modified to suit user preference as to keys for special functions. Among features: plotting of any number of values of dependent variable versus one value of independent variable; provision for introduction of error signals to correct incorrect points punched in tape; plotting of first three digits of numbers containing any number of digits.—*F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena, Calif.*

For more information circle **239** on inquiry card.

SHOP EQUIPMENT and SUPPLIES

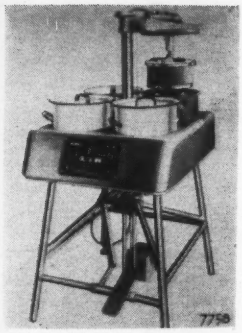
HIGH-PRECISION LINEAR-MOTION MACHINE DRIVE

New "Inchworm Motor" feed mechanism, accurately controllable to microinches, is said to be "a logical successor to the lead screw in all mechanisms requiring microinch dimensional control." Name "Inchworm" aptly describes mode of operation: device literally steps along in microinch steps, expanding and contracting like its familiar green namesake. Employing magnetostrictive effect, armature shrinks in magnetic field, snapping back to original size when field is de-energized. A pair of clamps cooperating with armature converts expansions and contractions into forward or backward motion, reversing on demand without backlash. "Inchworm" is suitable for automatic control of machine tools because it can be commanded by gage signals. —*Airborne Instruments Lab., Inc., 160 Old Country Rd., Mineola, N. Y.*

For more information circle **240** on inquiry card.

CLEANING MACHINE

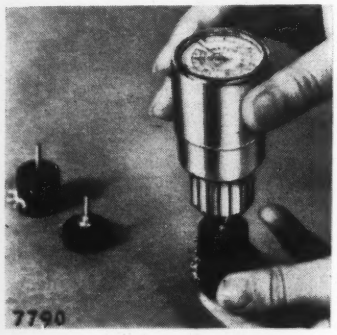
New "Monarch" industrial all-parts cleaning machine provides greater capacity, more durable construction and a more efficient cleaning operation on instruments, clocks, small parts, etc., than previous models; is said to be ideally suited for incorporation into production and maintenance department as well as industrial repair stations.—*L & R Mfg. Co., 577 Elm St., Arlington, N. J.*



For more information circle **241** on inquiry card.

BIDIRECTIONAL TORQUE GAGE

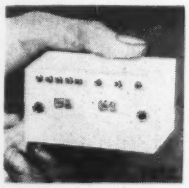
New "Model 6500" of maker's "Torque-Watch" reads clockwise and counterclockwise torque on two linear scales, each spread over 300° on a 1" dial. Scales are of different colors. Ranges of 0.1 to 1.2 and 1.0 to 20 oz-in are standard; others special.



★New "Model B Torque Watch" embodies new design features based on user reactions to first model: longer outer shell for firmer grip; chuck has re-designed to take ¼" shafts as short as 1/16"; crystal recessed and flat to lessen risk of breakage and allow gage to be set on end.—*Waters Manufacturing, Inc., P. O. Box 368, So. Sudbury, Mass.*

For more information circle **242** on inquiry card.

POTTING COMPOUND



New "E-P-Fome," said to be "the first nontoxic foam-in-place potting compound," is light in weight and safe to handle. Foaming reaction takes place at room temperature without pressure to rapidly produce semi-rigid or rigid foams with controlled densities from 3 to 30 lb/ft³. Continuous service from −80°F to 250°F.—*Electronic Plastics Corp., 675 Barbey St., Brooklyn, N.Y.*

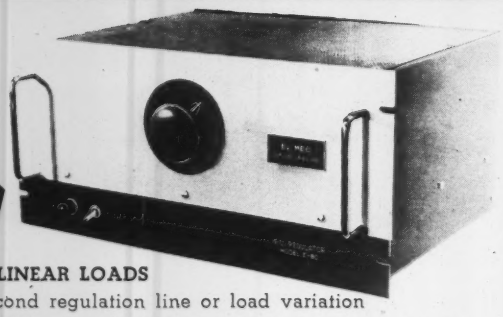
For more information circle **243** on inquiry card.

FOR Really HIGH SPEED RESPONSE

TRY THE NEW
el mec
A.C. REGULATOR

60 OR 400 CYCLES

IN A CLASS BY ITSELF



- IDEAL EVEN FOR NON-LINEAR LOADS
- HIGH SPEED – 1 millisecond regulation line or load variation
- SUPPRESSES HARMONICS – Less than 2% harmonics in output even with 10% input distortion
- PROVEN by continuous trouble free use in automatic equipment

The A.C. Regulator you've been waiting for – and you can prove it for yourself. Don't delay, order the model you require today.

Model	Specifications		
E-80-1	115 V.	1.5 Amp.	60 Cycles
E-80-1V	Variable 50-125 V.	1.5 Amp.	60 Cycles
E-80-2	115 V.	2.5 Amp.	60 Cycles
E-80-2V	Variable 50-125 V.	2.5 Amp.	60 Cycles
E-84-2	115 V.	2.5 Amp.	400 Cycles

D.C. REGULATORS TOO!

If you are quality conscious and insist on your D.C. power supplies being dependable, conservatively rated, carefully specified, and properly built – then El Mec should be your source. Send for a supply of design data sheets and submit your specifications. We will be happy to send you an engineered quotation or have our representative call.

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LABORATORIES, INC.
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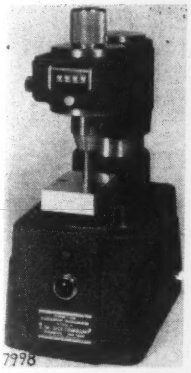
For more information circle **74** on inquiry card.

DIMENSIONAL GAGING and INSPECTION

DIGITAL READOUT AUTOMATIC MICROMETER

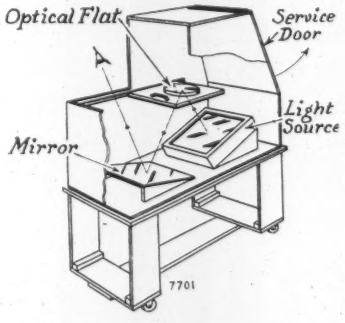


New "Model HDR Carson-Dice Digital Readout Electronic Micrometer," first of its kind, eliminates human error sources; takes standard anvil or special fixtures. Repeatability is 20 microinches. Operating cycle is several times faster than best manual-operation speed: Micrometer spindle is lifted by pushing lever switch to rear; work is placed on anvil; then lever switch is pushed forward and held until measurement is completed as indicated by green light under counter. Upon release of lever switch, spindle automatically backs off to permit removal of work. Option: foot switch to free both hands. —*J. W. Dice Co., Englewood, N. J.*

For more information circle **244** on inquiry card.

MONOCHROMATIC LAMPS

Two new floor-model monochrommatic lamps are inverted, so that parts can be inspected on the optical



flat rather than moving the flat onto the part. This new method avoids distorting thin parts by weight of flat and obviates handling heavy flats with risk of damage. Both models take workpieces up to 8½" dia, using flats as large as 10" dia.—*Acme Scientific Co., 1452 West Randolph St., Chicago 7, Ill.*

For more information circle **245** on inquiry card.

ELECTRONIC CALIPER

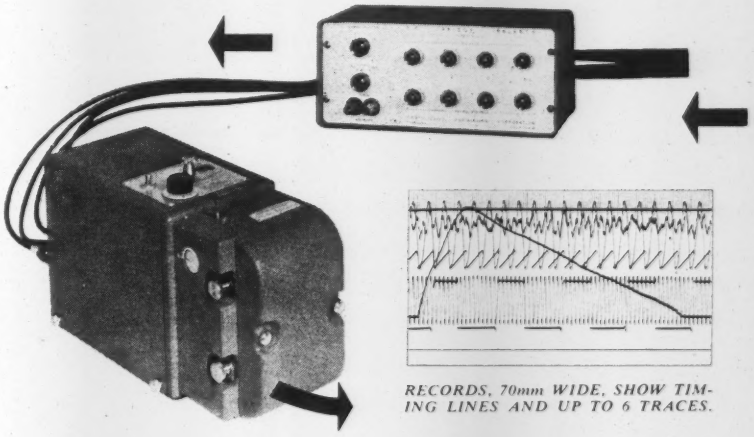
New "No. 955" electronic caliper has a wide size range (from 0" to 4") obtained by a series of four jaws interchangeable on a common aluminum body by removing three steel screws. Ordinarily, threads tapped into alu-

new high in performance

new low in cost

This combination of Consolidated's 6-channel 5-117 Recording Oscillograph and 8-110 Bridge Balance fills the long-standing gap between pen-type recorders and complex oscillograph/amplifier systems . . . provides high-speed, graphic records of physical phenomena invaluable in research and development, product analysis, and clinical diagnosis. Stress, strain, vibration, pressure, temperature . . . measure them all at the same time for a *true picture* of either a product or a patient. The system is so simple to operate that no special electronic experience is needed . . . and so light that it can be carried anywhere. You'll find dozens of applications for it in your laboratory, your plant, or your clinic.

A COMPLETE RECORDING SYSTEM FOR DYNAMIC TESTING



RECORDS, 70mm WIDE, SHOW TIMING LINES AND UP TO 6 TRACES.

5-117 Recording Oscillograph . . . records up to 6 channels of data *without amplifiers* at frequencies to 200 cps (with amplifiers, to 3000 cps). Uses 70-mm by 100-ft paper or film, driven ¾" to 24"/sec. Timing lines appear every 1/100 second. Bulletin CEC 1533B-X5.

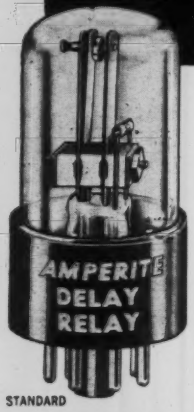
8-110 Strain-Gage Bridge Balance . . . 4-channel control link between oscillograph and strain gages or resistance-type pickups. Has controls for balancing and adjusting d-c voltage across each channel and provision for calibration resistor. Send for Bulletin CEC 1560-X12.

Consolidated Electrodynamics
CORPORATION
formerly Consolidated Engineering Corporation
300 North Sierra Madre Villa, Pasadena, California
ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL
Sales and Service Offices in: Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.

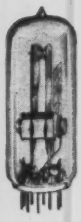
For more information circle **75** on inquiry card.

True Hermetic Sealing assures Maximum Stability in AMPERITE RELAYS and REGULATORS

Simplest • Most Compact • Most Economical



STANDARD


MINIATURE

Thermostatic DELAY RELAYS

2 to 180 Seconds

- Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.
- *Hermetically sealed.* Not affected by altitude, moisture, or other climate changes.
- *SPST only* — normally open or normally closed.

Amperite Thermostatic Delay Relays are compensated for ambient temperature changes from −55° to +70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are *most compact, rugged, explosion-proof, long-lived,* and — *inexpensive!*

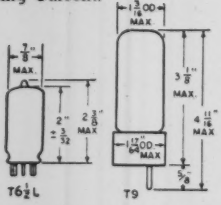
TYPES: Standard Radio Octal, and 9-Pin Miniature

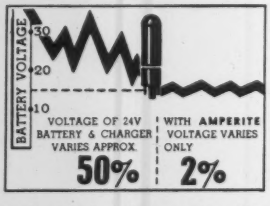
PROBLEM? Send for Bulletin No. TR-81

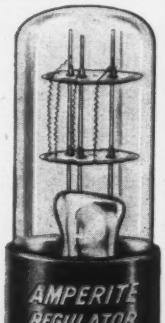
Also — **Amperite Differential Relays:** Used for *automatic overload, under-voltage* or *under-current protection.*

BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit ***automatically regulated*** at a definite value (for example, 0.5 amp.) . . . For currents of 60 ma. to 5 amps. Operate on A.C., D.C., Pulsating Current.







T9 BULB

Hermetically sealed, they are not affected by changes in altitude, ambient temperature (−55° to +90° C.), or humidity . . . Rugged, light, compact, most inexpensive.

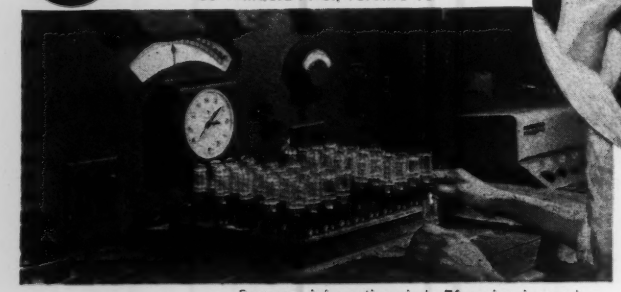
Write for 4-page Technical Bulletin No. AB-51

AMPERITE CO., Inc.

561 Broadway, New York 12, N. Y.

Telephone: CAnal 6-1446

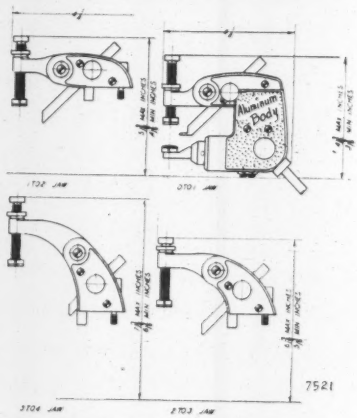
In Canada: Atlas Radio Corp., Ltd.
50 Wingold Ave., Toronto 10



Individual inspection and double-checking assures top quality of Amperite products.

For more information circle **76** on inquiry card.

NEW INSTRUMENTS

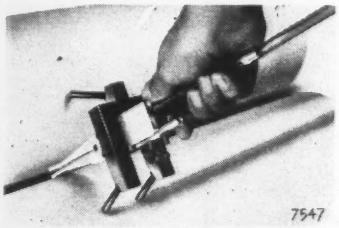


minum tend to wear and strip during frequent assembly and disassembly. In new B&S caliper, however, stainless steel wire thread inserts (mfd by Heli-Coil Corp., Danbury, Conn.) are installed in aluminum body to provide strong permanent threads.—*Brown & Sharpe Mfg. Co., Providence, R. I.*

For more information circle **246** on inquiry card.

CALENDER ROLLS GAGE

New "Model A-149 P-1" air-caliper gage provides direct measuring for spacing between calender rolls so that

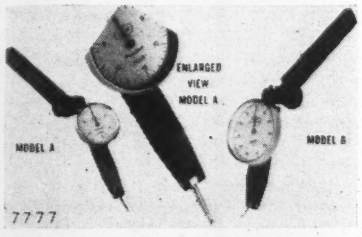


user can determine whether rolls have been ground correctly all the way across.—*Federal Products Corp.,* 1144 *Eddy St., Providence* 1, *R. I.*

For more information circle **247** on inquiry card.

DIAL INDICATORS

New improved models of "Puppitast Universal Test Indicators" feature shockproof movements and contact



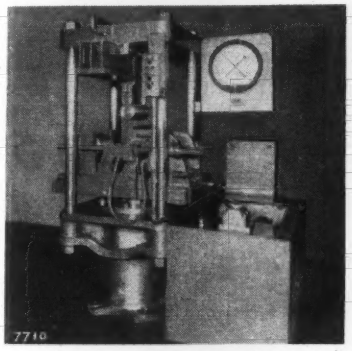
points with a threaded base, making possible interchanging contact points within seconds. "Model A" reads in 0.0005" with 0.03" total range; "Model B" reads in 0.0001" with 0.01" range.—*George Scherr Co., Inc.,* 200 *Lafayette St., New York* 13, *N. Y.*

For more information circle **248** on inquiry card.

MECHANICAL TESTING

COLD-BEND TESTER

New testing machine for making cold bending tests quickly under loads up to 150,000 lb accepts low-carbon

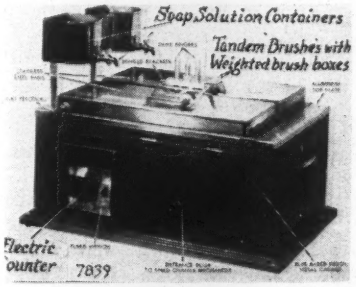


steel bars and flats in lengths of 5" to 24"; is hydraulically operated at controllable table speeds of 1.5" (or less) to 10" per minute. Maximum upward stroke is 11".—*Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.*

For more information circle **249** on inquiry card.

HEAVY-DUTY WEAR TESTER

New "Item 1725" makes possible measurements, performance tests, sales demonstrations, etc., of paints,

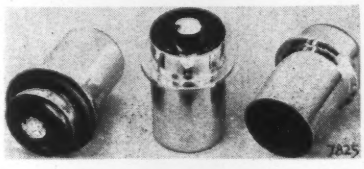


varnishes, plastics, ceramics, etc. It measures washability, scrubbability, durability, removability; resistance to abrasion, to gloss changes, to reflectance changes, to stain removal; cleaning efficiency; etc.; in accordance with many US and state gov't specs.—*Gardner Laboratory, Inc., P.O. Box 5728, Bethesda 14, Md.*

For more information circle **250** on inquiry card.

ULTRASONIC TRANSDUCER

New "High Resolving Transducer" enables detection of small flaws close to specimen surface by ultrasonic



MODEL "M" SERIES

Marksman tubeless electronic potentiometer strip chart RECORDER for recording and controlling such variables as temperature, speed, strain, pH and many others.

- No vacuum tubes. Sensitivity of 5 micro-volts or less.
- Potentiometer for thermocouple (TCB protected) or radiation pickup, Wheatstone bridge for resistance pickup.
- Full selection of standard scale ranges . . . 11" calibrated chart width.
- Selector knob changes chart speed . . . 5 speeds per unit without gear change.
- Single or multi-record units available.
- Equipped for 115 or 230 volts — no transformers needed.
- Additional features: Automatic standardization . . . cold junction compensation for thermocouple use . . . battery condition indicator for potentiometer . . . built-in chart saver . . . designed for standard 19" relay rack.

INSTRUMENT SHOW BOOTH 625

WEST Instrument CORPORATION
SALES OFFICES IN PRINCIPAL CITIES
4355 W. MONTROSE, CHICAGO 41, ILL.
British Plant: WEST INSTRUMENT LTD.
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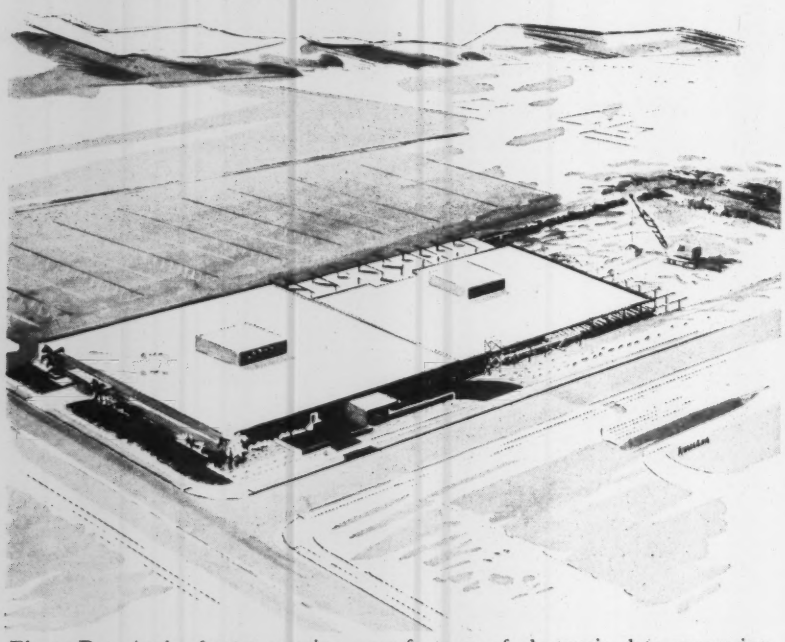
NOW you can have all these practical advantages in a single instrument. Write for Bulletin M.

the trend is to **WEST**

For more information circle **77** on inquiry card.

ElectroData
IS EXPANDING...

Headquarter facilities in Pasadena are *again* being doubled to keep pace with the demand for DATATRON systems.



ElectroData is the fastest growing manufacturer of electronic data processing machines, and has immediate openings for:

CUSTOMER SERVICE ENGINEERS
SYSTEM EVALUATION ENGINEERS

Desirable qualifications are a degree in electrical engineering or graduate of an accredited industrial electronics school. Military radar experience or maintenance of digital computers or complex electronic equipment may be substituted for academic training.

Customer Service Engineers will be in charge of an ElectroData data processing installation. These positions exist nation-wide.

Systems Evaluation Engineers will supervise an engineering team in the final checkout and evaluation of digital computer systems.

ElectroData policy is to pay *top salaries* to men of proven capabilities. Company benefits are liberal and include:

- **Comprehensive Insurance and Retirement Program.**
- **Personal recognition.**
- **Extensive training program.**
- **Relocation expense.**
- **Salary and expense during training.**

In confidence write:

MR. LEO THOMAS
Engineering Coordinator

ElectroData DIVISION OF BURROUGHS

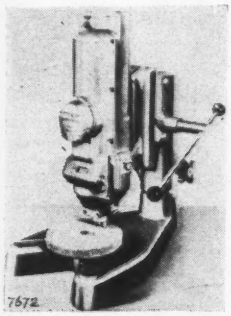
460 SIERRA MADRE VILLA, PASADENA, CALIFORNIA

echosounding methods; also differentiation between two defects in one minute area. When it is used with a suitable instrument such as maker's "Immerscope," it can detect a 0.046"-dia round plane flaw at a distance of 0.1" below surface of an aluminum specimen, while a quartz crystal transducer would be able to "see" such a flaw only up to 0.3" from surface.—*Curtiss-Wright Corp., Caldwell, N. J.*

For more information circle **251** on inquiry card.

GRINDING-WHEEL TESTER

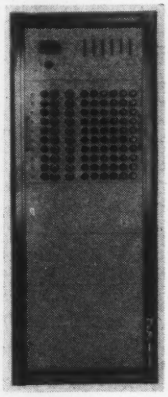
New "New Process Tester," for determination of hardness of grinding wheels, produces a dynamic test by



means of a reciprocating and rotating chisel held under a predetermined pressure. Conditions are as similar as possible to actual stress to which grain imbedded in wheel is subjected in actual use.—*George Scherr Co., 200 Lafayette St., New York 12, N. Y.*

For more information circle **252** on inquiry card.

FATIGUE-TEST CONTROLLER

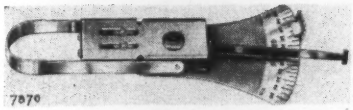


New automatic program controller for Baldwin-Sonntag Fatigue Testing Machines can be preset (1) to ten static load levels in either tension or compression and/or (2) ten dynamic load levels, each of which can be set (3) for any number of load cycles up to 999,999, (4) sequenced in any desired preset order of load levels for (5) any preset number of sequences.—*Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.*

For more information circle **253** on inquiry card.

SPRING TENSION GAGE

New "Spring Tension Gauge" for accurately determining settings, or for checking tensions of relay or other springs, has an adjustable tension attachment for zeroing gage's own spring. Scale is calibrated on

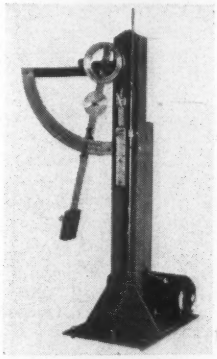


front and back so that gage can be used for indicating left to right or right to left. "No. STG-2-D" (illustrated) has scale to 50 grams on either side of center zero in 5-gram steps. Three other models, with 10-, 30- and 150-gram capacities.—*P. K. Neuses, Inc., W. Euclid & Dwyer Sts. Arlington Heights, Ill.*

For more information circle **254** on inquiry card.

TENSILE STRENGTH TESTERS

New improved models of maker's tensile strength testing machines, in capacities to 25 lb for paper, twine,

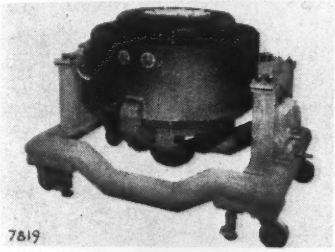


foil, film, etc., can be operated rapidly by unskilled personnel.—*Amthor Testing Instrument Co., 45 Van Sinderen Ave., Brooklyn 7, N. Y.*

For more information circle **255** on inquiry card.

VIBRATION SHAKER

New "Model 177" is one of a new series of "wide-band" shakers specifically designed for higher frequency



operation and lower input requirements than other models. Force rating 5000 lb; 412-lb load for 10-*G* vector and 162-lb for 20-*G*—*Calidyne Company, Winchester, Mass.*

For more information circle **256** on inquiry card.

INDUSTRIAL "STETHOSCOPE"

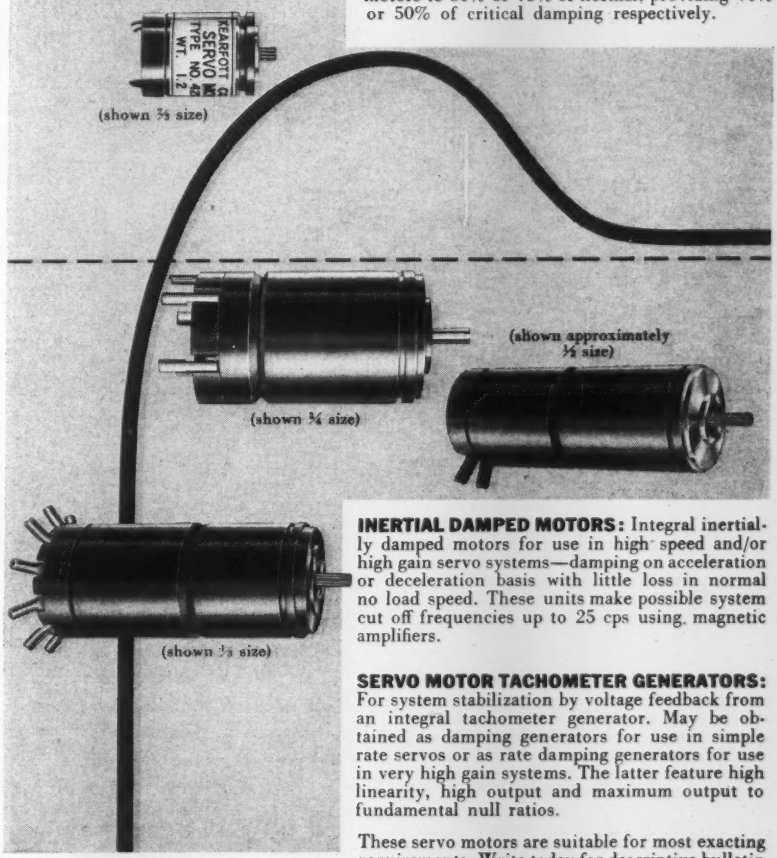
New model of "Sono-Probe" weighs 3 lb, is available with one or two interchangeable contact probe microphones of Rochelle salt crystal type: (1) for low-frequency range of 20 to 3,000 cps; (2) for high-frequency

There is no one "cure all" for system instability. The desired stability of a servo loop is attained through the proper selection of components that satisfy the various conditions under which the loop will operate. Kearfott offers four basic motors and combinations for providing system stability. All feature high speed of response; low inertia and high stall torque.

SYSTEM STABILITY

SERVO MOTORS: Servo motors with high torque to inertia characteristics possessing (built-in) inherent damping ranging in size from ¾" to 1¾" diameter are available. Low speed, low power motors for use in simple instrument servos where high damping and/or low time constant is required can also be provided.

VISCOUS DAMPED SERVO MOTORS: Provide integral viscous damping for simple instrument servos. Any degree of damping can be provided. These units reduce no load speed of standard motors to 50% or 75% of normal, providing 70% or 50% of critical damping respectively.



INERTIAL DAMPED MOTORS: Integral inertially damped motors for use in high speed and/or high gain servo systems—damping on acceleration or deceleration basis with little loss in normal no load speed. These units make possible system cut off frequencies up to 25 cps using magnetic amplifiers.

SERVO MOTOR TACHOMETER GENERATORS: For system stabilization by voltage feedback from an integral tachometer generator. May be obtained as damping generators for use in simple rate servos or as rate damping generators for use in very high gain systems. The latter feature high linearity, high output and maximum output to fundamental null ratios.

These servo motors are suitable for most exacting requirements. Write today for descriptive bulletin giving data of components of interest to you.

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

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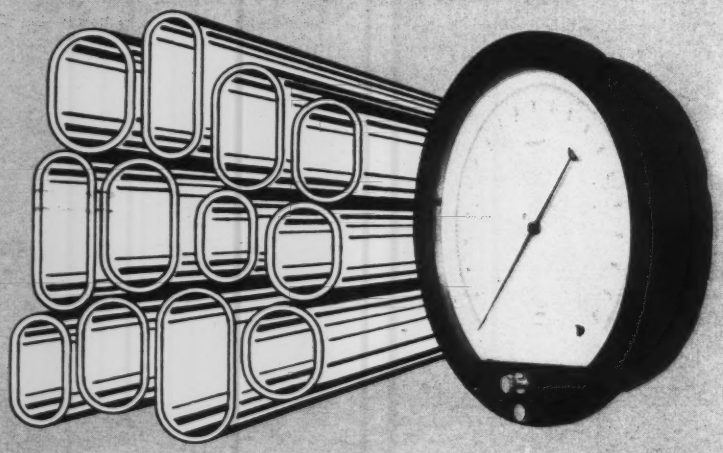
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

For more information circle **78** on inquiry card.

HEISE GAUGES

Designed for Dependability

Does your high pressure gauge application require a scientifically designed Bourdon Tube?



Where highly accurate results are required design considerations such as the depth — width ratio of the Bourdon Tube section are of paramount importance.

Extreme fiber stress resulting from improper design of the tube may render an apparently good instrument completely undependable.

At the Heise Laboratories, mathematical solutions for determining the size and shape of Bourdon Tubes for specific use are augmented by years of research and tests on various types of tubes to assure correct stress distribution.

Heise Bourdon Tubes are heat treated by scientific methods to guarantee that each tube will be metallurgically sound for its application. The precision heat treatment of thin walled tubing without distortion has been made possible by equipment and technique developed by Heise Laboratories.

Catalog on Request

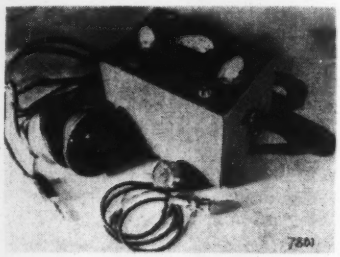
Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"—12"—16"

Prices from $151.60. **DELIVERY WITHIN 30 DAYS.**

HEISE BOURDON TUBE COMPANY, INC.
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **79** on inquiry card.

NEW INSTRUMENTS

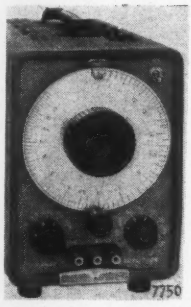


range of 100 to over 20,000 cps. Amplifier is a 3-stage wide-band stable unit with about 70 db gain.—*Advanced Electronics, Inc., 94 Silas Deane Highway, Rocky Hill, Conn.*

For more information circle **257** on inquiry card.

ELECTRICAL TESTING

1-cps TO 100-kc OSCILLATOR



New "Model 202C" multi-purpose low-frequency oscillator provides pure waveforms for subsonic, audio, and supersonic measurements in lab, field or plant; delivers high output power (160 mw) from a transformer-coupled balanced matched source. Frequency response is ±1 db full range. Output balance is better than 0.1% at lower frequencies and about 1% at 100 kc. Distortion is less than 0.5% above 5 cps and is independent of load impedance. Hum voltage is less than 0.1% of rated output.—*Hewlett-Packard Co., 275 Page Mill Road, Palo Alto, Calif.*

For more information circle **258** on inquiry card.

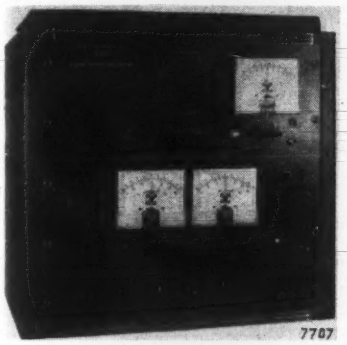
TRANSISTOR TESTER

New "Junction Transistor Checker" measures significant characteristics of *pnp* or *npn* transistors: collector leakage with base grounded, collector current at zero base current (base open) and base to collector current gain at 4.5 v on collector; reads gain directly. Other features: no warmup time; provision of pin jacks connected to base emitter and collector circuits for plugging in clip leads. Immediate delivery from stock.—*Instant Circuits Div., Alfred W. Barber Labs., 32-44 Francis Lewis Blvd., Flushing, N. Y.*

For more information circle **259** on inquiry card.

POWER TRANSISTOR TESTER

New "Model KP1" power transistor test set is designed to measure all hybrid parameters, including $l^{h}2l$ and

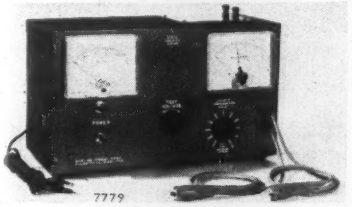


I_{eb} in either grounded-base or grounded-emitter configurations over a frequency range from 100 cps to 200 kc. Exclusive design feature: instrument can reverse either emitter current or collector voltage or both, to observe reverse dc characteristics of transistor under test.—*Baird Associates—Atomic Instrument Co., 33 University Road, Cambridge 38, Mass.*

For more information circle **260** on inquiry card.

H-V LEAKAGE TESTER

New "Model 103," for high-voltage ac breakdown testing of equipment when a maximum leakage current is

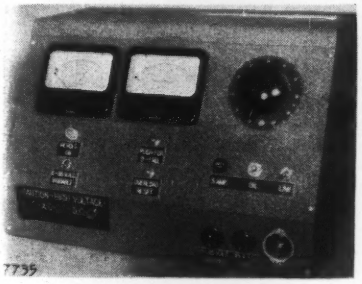


specified, provides from 400 to 2100 vac; cancels current due to electrostatic capacitance of tested article (up to 0.005 mfd) and checks insulation leakage only. Leakage limit can be set between 0 and 5 ma.—*Slaughter Company, Young & College Sts., Piqua, Ohio.*

For more information circle **261** on inquiry card.

HIGH-VOLTAGE TEST SET

New "Model 1015," added to maker's line of high-voltage test sets, delivers 10,000 vac or vdc, 15 ma, 0-15



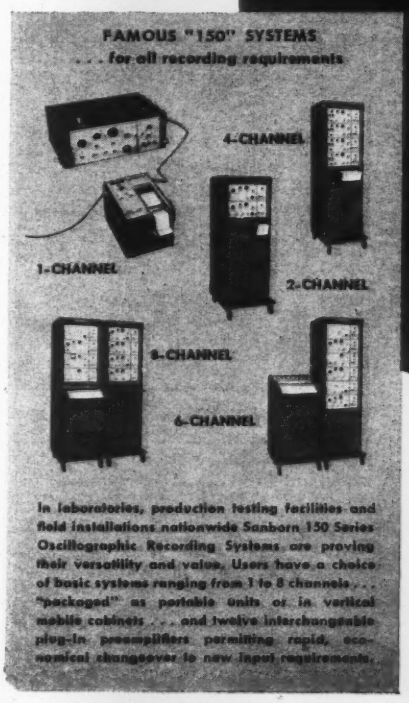
NEW 8 CHANNEL Sanborn oscillographic recording system

THIS new self-contained 8-channel oscillographic recording system, primarily for (but not limited to) analog computer recording, measures only 46½" x 27" x 22". In a single, space-saving mobile package, the user has a complete system for analog computer readout recording. Input cable connections are easily made at the top of the back panel. Eight groups of controls for the eight channels are conveniently located on the sloping top panel. Driver Amplifier chassis are easily withdrawn from the lower part of the console for inspection. Paper loading is quickly done from the top.

Features of the Model 158-5490 system include 0.1v/cm to 100v/cm sensitivity; over-all linearity of 0.25 mm over the entire 4 cm of the chart; drift less than 0.5 mm/hour; push-pull or single-ended input; miniaturized dual-channel DC amplifiers of improved current feedback design; 5 meg. input impedance each input lead to ground; true rectangular coordinate recording; nine chart speeds from 0.25 to 100 mm/sec. Frequency response is flat to 20 cps, down 3 db at 60 cps for all amplitudes to 4 cm peak to peak.

PRIMARILY FOR USE WITH ANALOG COMPUTERS

COMPLETE COMPACT SELF-CONTAINED



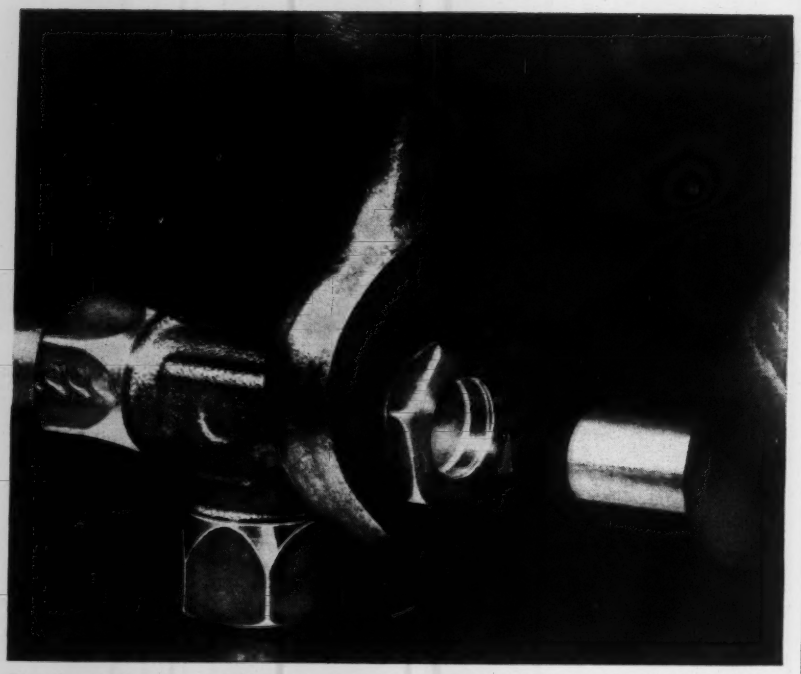
In laboratories, production testing facilities and field installations nationwide Sanborn 150 Series Oscillographic Recording Systems are proving their versatility and value. Users have a choice of basic systems ranging from 1 to 8 channels . . . "packaged" as portable units or in vertical mobile cabinets . . . and twelve interchangeable plug-in preamplifiers permitting rapid, economical changeover to new input requirements.

Sanborn will gladly furnish complete descriptive data on the new 158-5490 System and all "regular 150" systems, or engineering assistance on your recording problems, whenever you wish. Contact your Sanborn Representative, or write to

SANBORN COMPANY
INDUSTRIAL DIVISION
195 MASS. AVE., CAMBRIDGE 39, MASS.

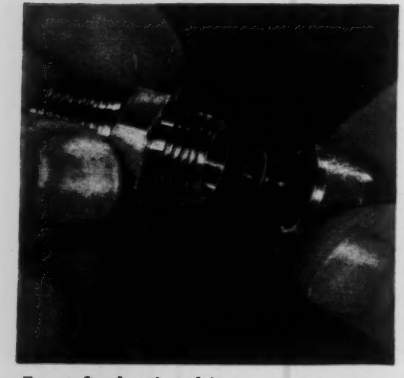
On display at Booth #811 Instrument-Automation Conference and Exhibit at New York Coliseum, September 17-21

For more information circle **80** on inquiry card.



Simply push, then tighten! Anyone can quickly install all-new, *lightweight Intru-lok* tube fittings . . . the proven Parker 3-piece flareless design. Just insert the tube, then tighten the nut with a regular wrench . . . for a leakproof, vibration-proof joint. Made of brass for copper or nylon tubing. Send for complete details in Catalog 4324.

Introducing easy-to-use
PARKER INTRU-LOK



For soft plastic tubing you use knurled nut and expander insert with new *Intru-lok* body. Joints can be disconnected and reassembled. Complete details in Catalog 4324. Send for it.

Weld-lok fittings, for extreme temperatures, corrosion conditions . . . machined from high-quality steel or stainless bar stock and forgings . . . for tubing ¼" through 2" O.D.

TUBE AND HOSE FITTINGS DIVISION
Section 415-K
The Parker Appliance Company • 17325 Euclid Ave., Cleveland 12, Ohio

Parker
Hydraulic and fluid system components

For more information circle **81** on inquiry card.

kv continuously-variable output; features adequate overload protection, pilot monitoring of switching, no extras to buy.—*Electro Devices, Inc.*, 4025 *Easton Ave., St. Louis* 13, *Mo.*

For more information circle **262** on inquiry card.

BRIDGE TEST SET

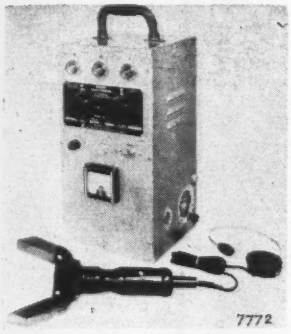
New "Model E-3155" complete Wheatstone bridge test set comes in a water-proof metal box; has all fea-

tures necessary to locate faults by means of Murray, Varley, Hilborne and other loop tests, and to measure resistance. Convenient switches are provided for making circuit changes. Galvanometer (1-uamp sensitivity) locks against breakage during transportation. Ratio resistors are accurate to 0.05%; rheostat resistors to 0.1%. Three push keys provide sensitivities of 0.01, 0.1 and 1 (or full) for galvanometer.—*Gray Instrument Co., Philadelphia, Pa.*

For more information circle **263** on inquiry card.

GROUND AND FAULT LOCATOR

New "Model 58 Brunt Faultfinder" is a combination ground detector and fault locator for use on normally un-

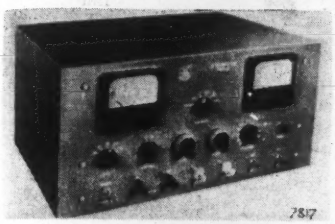


grounded power circuits while these circuits are energized; was especially designed for use in plants having several distribution centers of widely-separated voltages; can be used on voltages from 120 to 600, on circuits buried in earth or concrete, or on overhead circuits, without placing exploring coil on conduits or cables.—*Parr Mfg. Corp.*, 48 *Hale St., Cranford, N. J.*

For more information circle **264** on inquiry card.

POWER SUPPLY TESTER

New "Model 102 Electronic Load" combines all conventional instrumentation required for complete testing

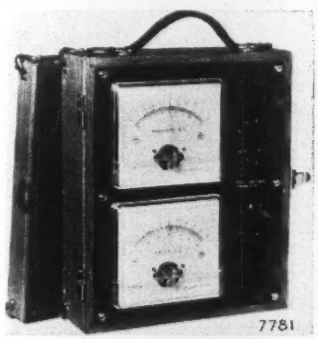


of regulated and unregulated power supplies; comprises a group of paralleled power tubes, a wide-band modulation amplifier, a variable bias supply, a mechanical keying device, and an ac VTVM.—*Electronics Div., Bristol Engineering Corp., Bristol, Penn.*

For more information circle **265** on inquiry card.

DUAL ELECTROLYSIS VM

New "Model G" comprises two zero-center dc voltmeters: upper VM has six ranges from 2.5 to 500 mv full-

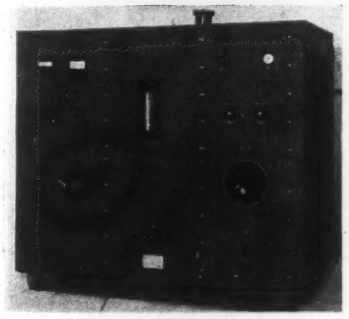


scale at a sensitivity of 2000 opv; lower has seven ranges from 0.3 to 300 v at a sensitivity of 50,000 opv; both are accurate to 1% of full-scale; their movements are specially designed for this unit.—*Stewart Bros. Div. Instrument Labs, 315 W. Walton Pl., Chicago 10, Ill.*

For more information circle **266** on inquiry card.

L-BAND R-F DUMMY LOAD AND CALORIMETER

New completely self-contained RF dummy load and calorimeter is designed for applications to high peak powers or high average power instal-



CINTEL

FLYING-SPOT PARTICLE RESOLVER

Automatic Counting and Sizing of particles down to 0.6μ are only two major features of the 'Cintel' Particle Resolver which presents a microscope subject on a picture tube.

High counting accuracy is ensured by a Magnetic Memory which eliminates double counts and the total is presented in 8 secs in decimal notation.

Particle sizes are analyzed electronically into 60 groups within the range 0.6 to 160μ, each group total being presented separately.

see it at:
I.S.A. show
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Sept. 17-21

SPECIFICATION:

Magnification: x200 to x8000 diameters.
Resolution: 0.1μ (1μ = 10^{-3} cm.)
Definition: 700 lines.
Picture Size: 8 x 8 ins.
Counting: Automatic. Minimum particle size 0.6μ.
Count Accuracy: ±2%.
Sizing: Automatic 0.6 to 160μ in 60 increments.
Size and Count Time: 8 secs.

The immense resolution, speed and accuracy of this new 'Cintel' tool brings automation to the physicist as well as the engineer.

Exclusive Sales and Service in U.S.A.

MARCONI instruments
44 New Street, New York 4, N. Y.

For more information circle **82** on inquiry card.

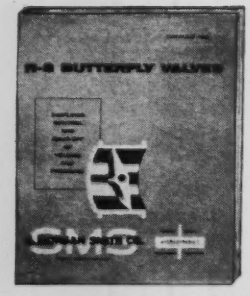
NOW YOU CAN SPECIFY STANDARD R-S BUTTERFLY VALVES FOR FASTER DELIVERY

R-S
BUTTERFLY VALVES

When the delivery date is important, you can get faster service on standard R-S Butterfly Valves. Based on the results of previous experience, R-S Valves are now standardized. All components for those most commonly used, in sizes from 4" to 48", are carried in stock, ready for assembly.

R-S Butterfly Valves give you positive, dependable performance. You get the advantages of:

- complete control in all positions of normal regulating range.
- fast regulation and closure.
- minimum pressure drop that saves power.
- compactness and light weight at less cost.



This new catalog will give you complete dimensions, specifications, layout drawings and materials for all R-S Butterfly Valves in the pressure ratings that have been standardized to date. As others are added, new sections will be published. To get a free copy and assure yourself of future sections, contact your SMS representative, or write to S. Morgan Smith Company, York, Pennsylvania.

HYDRAULIC TURBINES · GATES & HOISTS · TRASH RAKES · PUMPS · ACCESSORIES
HYDRODYNAMICS
ROTOVALVES · FREE-DISCHARGE VALVES · BALL VALVES · CONTROLLABLE-PITCH SHIP PROPELLERS · BUTTERFLY VALVES

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AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED • TORONTO

For more information circle **83** on inquiry card.

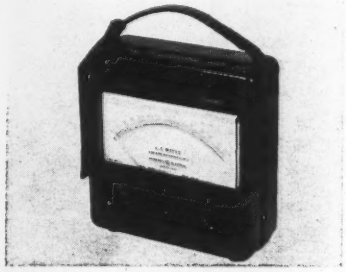
lations. As RF dummy load, it can handle over 2 Mw of peak power. For calorimetry, it uses a substitution method for greatest accuracy. A completely separate L-Band waveguide, with a waterload tube containing a 60-cycle Nichrome heater wire, is used as a calibrating load.—*Levinthal Electronic Products, Inc., 2903 Fair Oaks Ave., Redwood City, Calif.*

For more information circle **267** on inquiry card.

ELECTRICAL and ELECTRONIC INSTRUMENTS

PORTABLE STANDARD AND TEST-GRADE INSTRUMENTS

New high-accuracy portable indicating instruments with 5½" mirror scales are lower in price and require



less power from measured circuits than "Type P-3" being replaced. "Type AP-12" ac/dc portable standards have an accuracy of 0.25% full scale and matching "Type AP-11" ac/dc portables for general testing are accurate to 0.5% of full scale. In appearance all instruments match "DP-11 and DP-12" dc portables. All have two spring-mounted pivot bearings which virtually eliminate pivot blunting and cracked jewel bearings. —*General Electric Co., Schenectady 5, N. Y.*

For more information circle **268** on inquiry card.

SENSITIVE ELECTROMETER AND DC AMPLIFIER

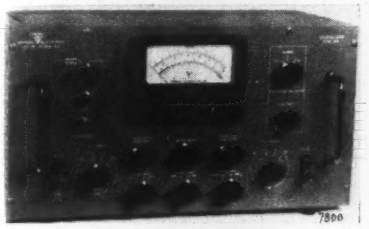
New "Type 1230-A D-C Amplifier and Electrometer" features excellent stability and high sensitivity for measurement of ionization currents,

bioelectric and contact potentials, etc. Internal resistance standards determine input resistance, which can be set in decade steps from 10,000 to 10^{11} ohms. Full-scale voltage ranges 30 mv to 10 v; full-scale current ranges 0.3 micro-microamp to 1 ma; 16 direct-reading resistance ranges 300 kilohms to 5×10^{14} ohms.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **269** on inquiry card.

ALTERNATING-VOLTAGE ANALYZER

New "Type 202 Vectorlyzer" can be used to measure (1) vector sum or difference of two voltages with ac-

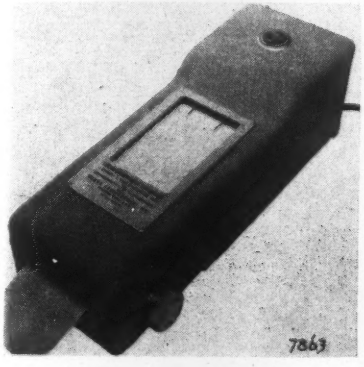


curacy of 1.5% and sensitivity of 0.04 rms full scale; (2) phase angle between two voltages with accuracy of 0.05° or 1.5% and sensitivity of 2° full-scale deflection; (3) imaginary and real components of an unknown voltage in terms of a reference voltage; (4) voltage across two points which are both above ac ground potential; (5) magnitude and phase angle of an unknown impedance; (6) ratio of two voltages. It "makes possible for the first time a number of measurements which were formerly impossible or at least very difficult."—*Advance Electronics Lab., Inc., 481 Highland Ave., Passaic, N. J.*

For more information circle **270** on inquiry card.

RECTILINEAR OSCILLOGRAPH

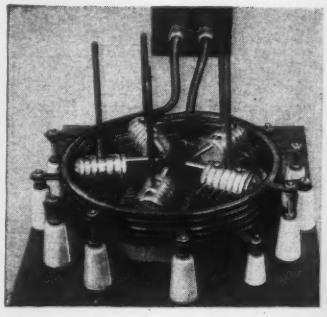
New "Electrodynamic Recorder Model GA 1023" features an electrodynamically driven mechanical system critically damped by an acoustic circuit, so that penmotor response is free of any resonance peak. Being a true non-resonant recording milliammeter, it requires no special amplifier compensation. Other features



The Lepel line of Induction heating units represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating. With a background of half a century of electrical and metallurgical experience, the name Lepel has become the symbol for quality in induction heating equipment embodying the highest standards of engineering achievement, dependable low cost operation and safety.

If you are interested in the application of induction heating you are invited to send samples of the work with specifications of the operations to be performed. Our engineers will process these samples and return the completed job with full data and recommendations without any cost or obligation.

TYPICAL INDUCTION HEATING APPLICATIONS

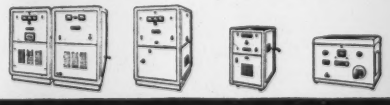


A widely used application in which several assemblies, consisting of a brass body, six radiator fins and a mounting stud, are being soldered simultaneously. The production of similar parts can be further increased by using two work coils and a change-over switch.

The illustration shows a lens grinding block being heated within the dome-shaped work coil. The heat generated in the metal block softens the pitch enabling the operator to remove the ground lenses and insert the next batch. The entire operation is completed in a few seconds.

Electronic Tube Generators—1 KW; 2½KW; 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.
Spark Gap Converters 2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

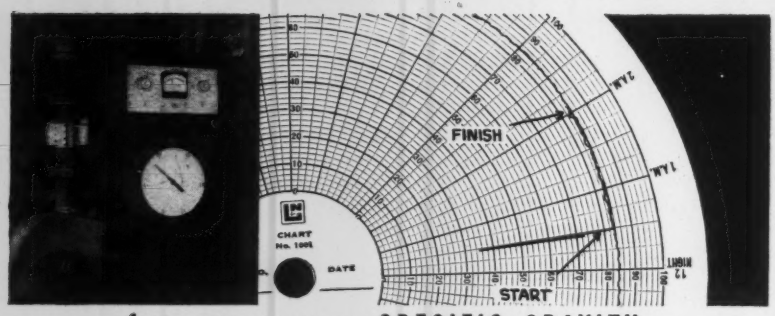
WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.



All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

For more information circle **84** on inquiry card.



for narrow span SPECIFIC GRAVITY, DENSITY, PERCENT OF SOLIDS measurement

OHMART offers

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- **3.0** #/CU FT
- **5.0** % SOLIDS

with 1% of scale precision*

NO moving parts and

NO contact with material being measured

ohmart gages provide	they are not affected by
high precision	temperature
low maintenance	viscosity
dependability	flow
flexibility	pressure
ruggedness	corrosion
safety	abrasion
	agglomeration
	vibration

With an Ohmart Gage you are assured of minimum sampling error—the measurement is made directly on the pipe containing the material by means of gamma ray absorption and the exclusive Ohmart Cell.

Complete accessories available for all operating conditions requiring weather-proof and explosion-proof housings, automatic temperature compensation, and multipoint or multirange installations.

All Ohmart Gages may be used with *standard* potentiometric recorders or controllers.

*When used on 10" pipe. With larger pipe, sensativity increased; with smaller pipe, sensativity decreased.

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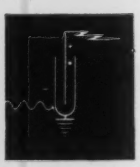
Radioactivity Gages Designed Engineered and Built for Industry



Representatives in most Major Areas. For additional information contact

the ohmart corp.

2236 Bogen Street
Cincinnati 14, Ohio

For more information circle **85** on inquiry card.

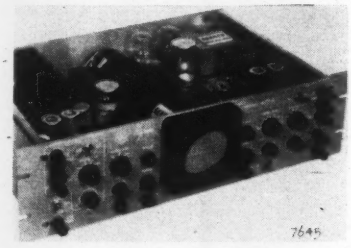
NEW INSTRUMENTS

include uniform frequency response (dc to 200 cps), excellent transient response, freedom from distortions due to overshoot and ringing; sensitivity 20 ma rms for full-scale deflection.—*Massa Laboratories, Inc., Hingham, Mass.*

For more information circle **271** on inquiry card.

INDUSTRIAL OSCILLOSCOPE

New low-frequency industrial oscilloscope of unusually compact design is sensitive to both direct and alternat-

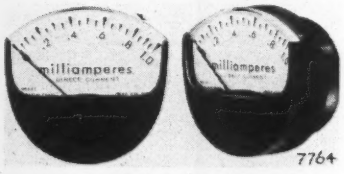


ing voltages and has identical horizontal and vertical amplifiers to assure accurate phase angle measurement; features usable response up to 500 kc (flat within 3 db from 0 to 300 kc); built-in calibration voltage; flat CRT.—*Hycon Mfg. Co., 2961 E. Colorado St., Pasadena 8, Calif.*

For more information circle **272** on inquiry card.

PANEL INDICATOR

New 1½" size of "Medalist" is said to provide readability equal to or better than conventional 2½" round in-

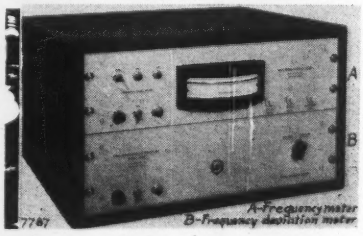


struments. "Plexiglas" case, for shadow-free scale illumination from all angles, is available in many standard and special colors. All standard ranges; self-contained accessories.—*Marion Electrical Instrument Co., Grenier Field, Manchester, N. H.*

For more information circle **273** on inquiry card.

400-CPS FREQUENCY METER

New "Model 6503" frequency meter for 397-403-cps range features accuracy of better than 0.01%; is insensi-

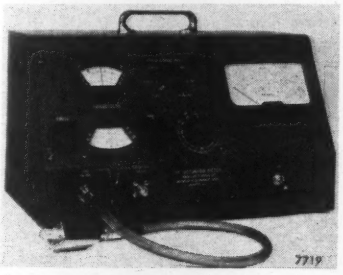


tive to waveform; accurately measures repetition rate of voltage spikes, sawtooth waveforms, etc.; accepts any input signal voltage between 6 and 250 v without need for adjustment. It consists of a "Model 6600 Frequency Deviation Multiplier" (which multiplies by ten the difference between the measured frequency and 400 cps) and "Model 6505A Frequency Meter."—*Varo Mfg. Co., Inc., 2201 Garland St., Garland, Texas.*

For more information circle **274** on inquiry card.

DISTORTION METER

New version of maker's "Model 85B, modified to permit its use either as a distortion meter or as a sensitive

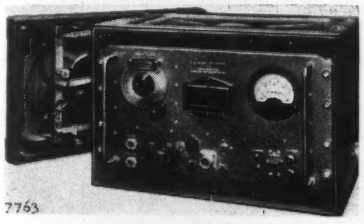


broadband RF voltmeter, can measure total distortion of RF source from 1 to 100 Mc. Used with a 50-ohm or a high-impedance probe, voltmeter section has a range of 1 mv to 3 v from 0.2 to 400 Mc. As an ultra-sensitive wattmeter, instrument reads down to 0.02 uw.—*Boonton Electronics Corp., 738 Speedwell Avenue, Morris Plains, N. J.*

For more information circle **275** on inquiry card.

FM DEVIATION METER

New FM Deviation Meter for telemetering and other wide deviation systems features extended range and



high stability. Carrier frequency is 20 to 500 Mc; deviation is measured to accuracy of 3% in range ±2 to ±400 kc; crystal standardization is built-in. Instrument accepts modulation frequencies from 50 cps to 120 kc. Use of counter type discriminator assures linearity and freedom from drift.—*Marconi Instruments, 44 New Street, New York 4, N. Y.*

For more information circle **276** on inquiry card.

DIGITAL VOLTMETERS

New "Models 1300, 1400 and 1500" for continuous operation feature a new design concept: use of mercury-wetted contact relays assuring life expectancy of more than one billion

CHATILLON

ISO-ELASTIC* TUNING FORKS

Insure constant frequencies through wide temperature variations

AMAZING ALLOY AUTOMATICALLY COMPENSATES FOR TEMPERATURE CHANGES FROM −50°F TO +150°F

Chatillon, maker of "the World's Most Accurate Spring" also produces Tuning Forks made of Iso-Elastic alloy for the Instrument and Electronic Field.

This remarkable, Chatillon developed alloy lends itself particularly to Tuning Fork applications due to its hysteresis error of less than .05% of deflection, drift not exceeding .02% of deflection in 5 minutes plus automatic compensation for temperature changes from −50°F to +150°F. Thermostatic control systems for the maintenance of constant temperatures are thus unnecessary. Chatillon Iso-Elastic Tuning Forks are used by General Electric Co., Daystrom Instrument and others.

CHATILLON makes Spiral, Torsion, Compression and Form Springs of Iso-Elastic material, as well as springs of conventional alloys

For Formal quotation on your complete Tuning Fork specifications and quantity requirements, write or wire CHATILLON SPRING DIVISION.

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JOHN CHATILLON & SONS 85 CLIFF STREET, NEW YORK, N. Y.

Manufacturers of Precision Springs and Measuring Apparatus Since 1835

For more information circle **86** on inquiry card.

"Varec" AUTOMATIC TANK GAUGES

MAGNETIC DRIVE for HIGH PRESSURE PETROCHEMICAL SERVICE

FIG. NO.
2500C

When you buy automatic tank gauges for petrochemical service – accuracy and safety are important requisites. "Varec" offers you both. Accuracy is assured by counter and dial reading, clear and distinct–without the danger of parallax or difficulty of reading a scummy tape. Dependable safety is insured by the magnetic drive rotating the counter and dial reading mechanism, Remote Gauger Transmitter or other auxiliary equipment. Prevents pressurizing sight glass chamber or transmitter housing. Isolates both from corrosive or dangerous tank vapors. Sight glass is kept clear without use of wiper. No danger to personnel by possible glass breakage.

In addition to these exclusive features, the Fig. No. 2500C and Fig. No. 2500CR have a host of advantages:

1. Neg'ator motor for motive power.
2. S.S. type 316 sheaves.
3. Shielded type 316 ball bearings.
4. All parts either 316 S.S. or pure aluminum – natural electrical ground – no plastics.
5. Gravity compensator for product change.
6. Built to API Standard 2500 for custody transfer.

FIG. NO.
2500RC

"Varec" Fig. No. 2500C is designed for gauging liquid level of chemicals stored in high pressure spherical tanks. Gauge head has heavy carbon steel flange to permit bolting for high pressure service.
"Varec" Fig. No. 2500CR is an inverted design of the Fig. 2500C, permitting its use on all tanks, below or above ground, where top readings are required. Stainless steel tape connects from gauge head to float in a straight line, eliminating use of sheaves and brackets, thus reducing friction and promoting greater accuracy.
Both types are available in two operating pressure ranges: 150# p.s.i.g. and 300# p.s.i.g. These are only two of a wide variety of "Varec" Automatic Tank Gauges. All are designed to be combined with "Varec" Electronic or Pulse Code Telemetering equipment, remote gauging, temperature transmission, automatic tank switching, and remote controls.
Send for "Varec" Bulletin CP-3007 for information on the entire line of gauging equipment.

961.15

THE VAPOR RECOVERY SYSTEMS COMPANY
"Varec"
Compton, California, U. S. A.
Cable Address: Varec Compton Calif., (U.S.A.), All Codes

For more information circle **87** on inquiry card.

NEW INSTRUMENTS

accurate readings. All adjustments are eliminated, and only motion is armature flexure since there is no pivot. "Model 1500" (5 digits) has manually-selected ranges of 00.000 to 99.999 vdc positive or negative with resolution of 0.001 v and ±100.00 to ±999.99 vdc with resolution of 0.01 v; gives three complete readings per second with automatic polarity indication. "Model 1400" has a 4-digit readout, and "Model 1300" 3 digits, otherwise same.—*Non-Linear Systems Inc., Del Mar Airport, Del Mar, Calif.*

For more information circle **277** on inquiry card.

AC-DC DIGITAL VOLTMETER

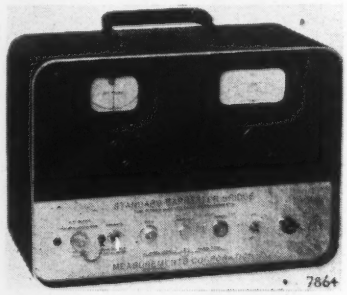
New 4-digit, ac-dc digital voltmeter automatically measures alternating voltages with 0.1-mv sensitivity.

Reading time averages two seconds on ac, and one second on dc readings. Range is 0.001 to 999.9 vdc and 0.0001 to 999.9 vac. Range switching manual on ac and automatic on dc; Stability 0.01% from 40°F to 120°F; automatic dc calibration; ac calibration set at factory, can be adjusted.—*Electro Instruments, Inc., 3794 Rosecrans St., San Diego, Calif.*

For more information circle **278** on inquiry card.

BARRETTER BRIDGE

New "Model 202-C Standard Barretter Bridge" features high accuracy and simplicity of operation,



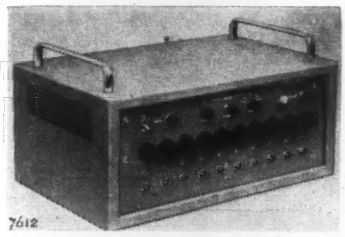
measures voltages from 20 to 70 mv rms and power from 8 to 100 microwatts in 50 ohms over a frequency range of 2 Mc to 1000 Mc. Resistive pads can extend voltage and power ranges upward. No special input probes or tuning for frequency correction are necessary.—*Measurements Corp., Boonton, N. J.*

For more information circle **279** on inquiry card.

ELECTR-INSTRUMENT ACCESSORIES

ELECTRONIC SWITCH

Newly redesigned "Beamplexer," fast electronic switch, samples up to ten separate signal sources and puts



them out in sequence on a single line. Among applications is enabling a single-channel 'scope to display up to ten separate channels of information simultaneously at a fraction of cost of a multi-channel 'scope.—*Burroughs Corp., Detroit 32, Mich.*

For more information circle **280** on inquiry card.

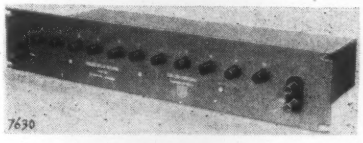
TRANSISTORIZED PLUG-IN PULSE CIRCUITS

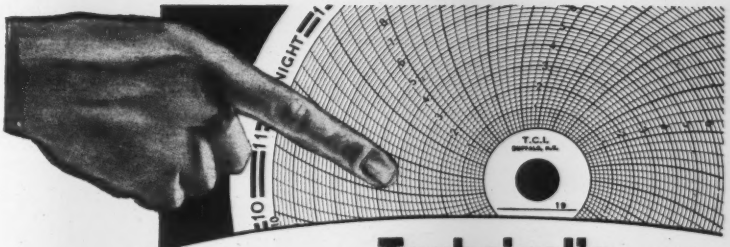
New transistorized multivibrators, binary counters, one-shot multivibrators, triggers, gated integrators, buffers, pulse-inverters, blocking oscillators, crystal oscillators, and relay drivers in compatible circuitry are mounted with standard Noval plugs. Units are ¾" dia by 2 5/8" high, weigh about 20 grams. Circuits will operate from 3 to 12 v with a maximum prf of 40 kc. —*Tripl-T Co., Box 352E, Pasadena, Calif.*

For more information circle **281** on inquiry card.

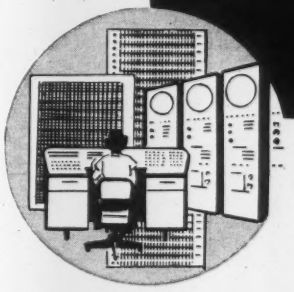
PUSHBUTTON DECADE DELAY LINES

New "Series #200" (mahogany cabinets) and "Series #200-R" (for standard relay rack) pushbutton dec-



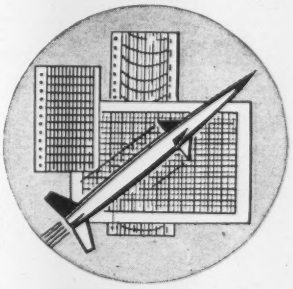


Technical's RECORDING CHART SERVICE has application for you



DIGITAL COMPUTER RECORDS . . .

Are you satisfied with your present computer recording forms? Contact **Technical** for help in developing computer or tabulating machine forms best suited for your statistical applications. Information on **Technical's** "know-how" with computer papers sent upon request.



"SPECIAL" RECORDING CHARTS . . .

for new instruments or unusual process needs!

Charts are vital to the **new recording instrument** design. Be sure you contact **Technical** when your project begins and eliminate recording problems at the start! For standard instruments recording under unusual process conditions, **Technical** can supply "Special" charts on heat or electro sensitive and other papers. Send for "Technical Notes" containing helpful new chart specifications.

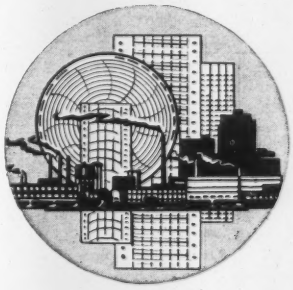


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Chart supply is easy . . . and operating costs are less . . . when you suggest to your purchasing men to buy **all** their chart needs from **Technical. Technical's** acceptance by large and small "Blue Chip" companies is testimony of high chart quality. Automatic order processing and inventory control assure fast service. Write for Catalog 56 and stock list.

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For more information circle **88** on inquiry card.

NEW PRECISION TRANS VOLT-AMMETER IS THE ELECTRICAL ENGINEER'S MICROSCOPE

Now available with Voltage Multipliers for extended range: 3.0 volt scale to 1250 volt scale

. . . a precision, A. C., multi-range instrument with an accuracy of 1/20th of 1% (0.05%) through a frequency range from 20 to 20,000 cycles per second.

- Surpasses lab-standard accuracy
- Extremely wide frequency range—many times higher than conventional lab-standards
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- Outstandingly suited for checking other instruments
- No corrections needed to obtain this high degree of accuracy
- High life expectancy—low cost
- Simple, economical maintenance
- Skilled personnel not required
- Portable—weighs less than 25 lbs.

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For more information circle **89** on inquiry card.

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—unsurpassed in accuracy, it is quick-acting, light-weight and rugged. Features large 4¼" direct reading dial. Measures both surface and sub-surface temperatures with selection of thermocouples and extension arms. Has cold-end junction compensator (operates automatically) and shielded steel housing. Available in five standard ranges: 0-300° F. to 0-1200° F.; also special and sub-zero ranges. Write for free Catalog #168.

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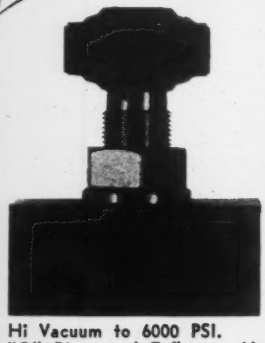
Manufacturers of Pyro Optical, Radiation, Immersion and Indicating Pyrometers for over 25 years. Ask for Catalogs.

For more information circle **90** on inquiry card.

ROBBINS **Leakproof Metering Valves**



- **Hi Vacuum to 6000 PSI.**
- **"O" Rings and Teflon or Nylon Seats are standard.**
- **Over-torquing cannot damage seat or needle as buffer plate and metering pin act as a forming die.**
- **Impossible to score needle or seat.**
- **Lifetime Valve—can be completely overhauled in a matter of minutes without disturbing plumbing or mounting.**
- **The most economical valve in the long run.**

Write for further details.

ROBBINS AVIATION
1735 W. Florence Ave., Los Angeles 47, Calif.

For more information circle **91** on inquiry card.

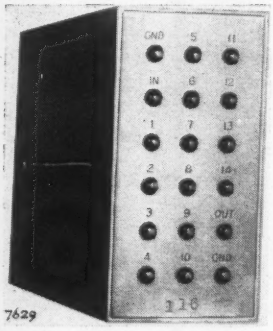
NEW INSTRUMENTS

ade delay lines can be terminated in their characteristic impedance at selected tap; provide a variable delay between matched impedances and, therefore, offer design flexibility necessary for lab work. Eight models, providing from 0-5-usec to 0-50-usec delays with accuracy 1% of selected delay, are available for quick deliveries.—*ESC Corp., 534 Bergen Blvd., Palisades Park, N. J.*

For more information circle **282** on inquiry card.

20-30 USEC DELAY LINE

New 2x4x8" lumped-constant delay line for telemetering, computers, pulse circuits, etc., features use of new

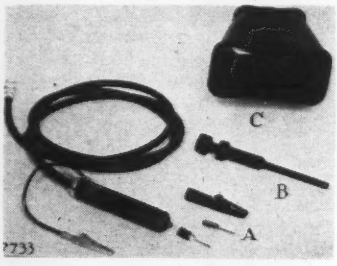


techniques and materials and design advances; features taps every 1.45 usec; tap accuracy 0.1 usec; rise time better than 0.7 usec; attenuation less than 4 db overall; meets MIL-T-945A. —*Epsco, Inc., 588 Commonwealth Ave., Boston, Mass.*

For more information circle **283** on inquiry card.

'SCOPE ACCESSORIES

New accessories for cathode-ray oscilloscopes: (A) "Type 2613 Fixed-Ratio Test Probe" general-purpose at-



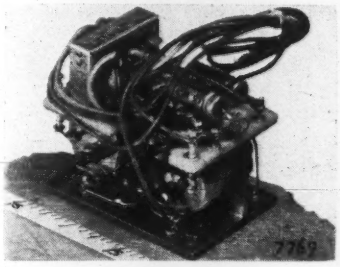
tenuator probe with 10-megohms input impedance permits observation of signals in circuits with high source impedance without loading circuit; comes with (left to right) snap-on tip for general probe use; needle-nose for insulation penetration; and insulated alligator clip. (B) "Type 3010" optional unit for test probe, 5" insulated spring-loaded auxiliary probe tip. (C) "Type 2621" rubber viewing hood with mounting clip.—*Technical Sales Dep't, Allen B. Du Mont Labs., Inc., 760 Bloomfield Ave., Clifton, N. J.*

For more information circle **284** on inquiry card.

AMPLIFIERS

SERVO AMPLIFIER

New transistorized servo amplifier assembly (shown before encapsulation) measures 1½x1½x1"; has un-



usually high power gain of 10^5 achieved by a "heat-sink" design which rapidly dissipates heat. Amplifier rating is 1 watt at 71°C ambient. Operating temperature range −55°C to 71°C.—*John Oster Mfg. Co., Avionic Div., Racine, Wis.*

For more information circle **285** on inquiry card.

HI-FI PREAMPLIFIER

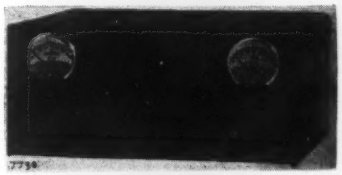
New "High Fidelity Preamplifier" is said to have "fullest control facilities and outstanding physical design. Utilizing recently-developed high-quality circuitry, it is suited for use with the finest power amplifiers in systems of the highest quality."—*Eico, 84 Withers St., Brooklyn 11, N. Y.*

For more information circle **286** on inquiry card.

POWER SUPPLIES, etc.

SUPPLIES FOR AUTOMATION

New "Models 231A, 232A and 233A Programmable Power Packs" feature unique circuit design for applications

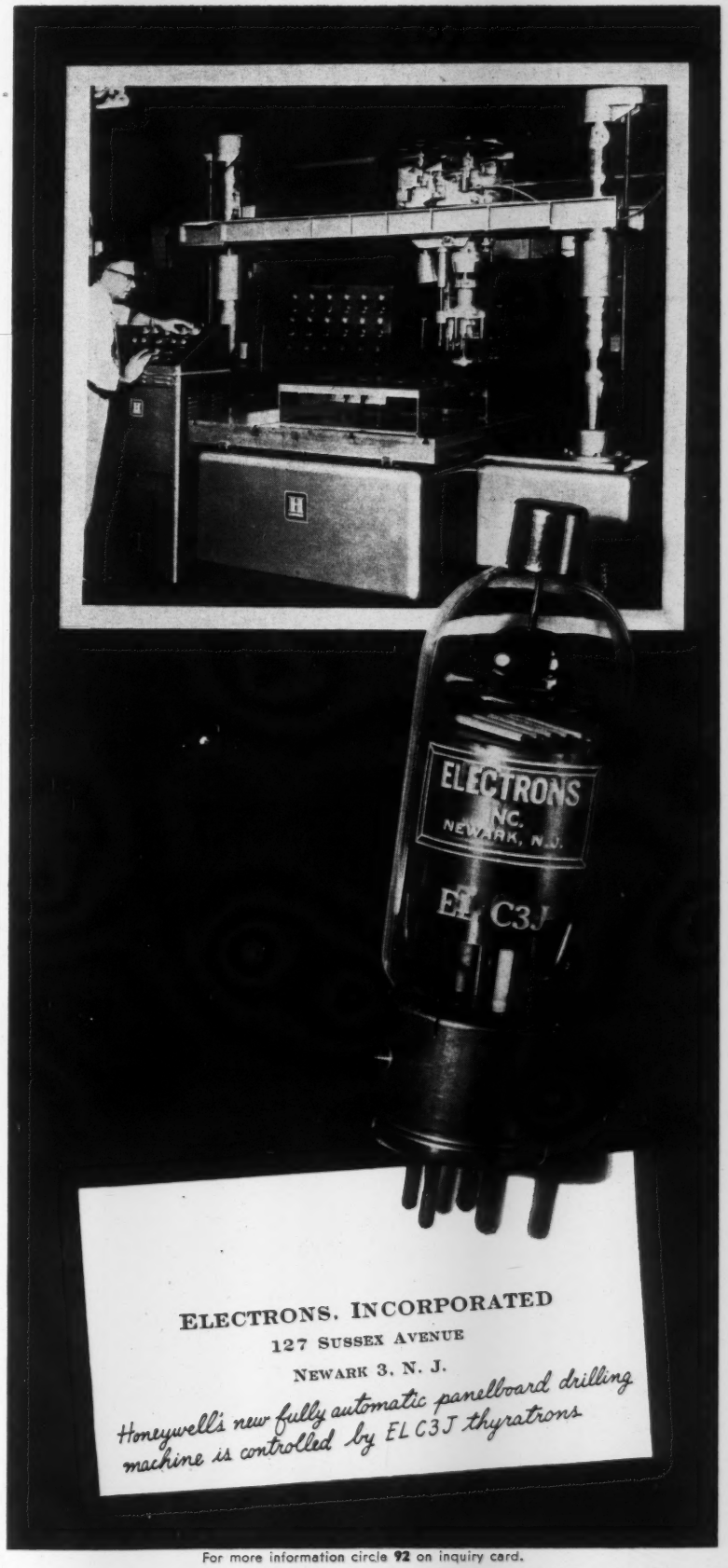


requiring remote control and/or programming according to commands from an operator or control system, as in tube-test programming, automatic production testing, etc.; also main and vernier controls, auxiliary bias and filament outputs. All have an output range of 0-300 v, regulation of 0.1 v. and ripple of only 1 mv. Current outputs respectively are 0-100 ma, 0-200 ma, and 0-300 ma.—*Electronic Measurements Co., Inc., Lewis St., Eatontown, N. J.*

For more information circle **287** on inquiry card.

INSTRUMENT POWER SUPPLIES

New "250 Series" low-voltage supplies, intended primarily for use with strain gages and similar pickups, fea-



For more information circle **92** on inquiry card.

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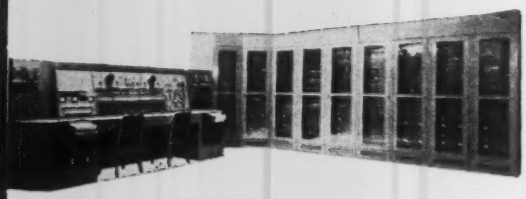
Where custom systems are involved, it just doesn't pay to do the work yourself. Not when EECO can do it for you—expertly, efficiently—without disrupting the normal productive activities of your engineering staff. Major EECO installations in operation in all parts of the country are proof of Electronic Engineering Company's ability to design and produce anything from single-rack recording systems to the most complex multi-console master installations. And EECO design techniques, perfected through years of systems work, are now ready to be put to work for you in an EECO engineered system to meet your exact requirements.



One wing of the EECO Central Dual Timing System at Patrick Air Force Base, Florida. This system is a master time signal generating installation for the base and ties in with all instrumentation operations for guided missile testing.

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For more information circle **93** on inquiry card.

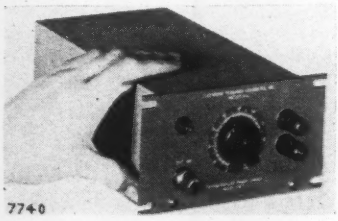
NEW INSTRUMENTS

ture isolation from power line and chassis ground: can be used ungrounded in bridge circuits feeding single-ended amplifiers, recorders, etc. Output is 6 or 10 vdc, adjustable ±1 v, less than 0.02% peak-to-peak ripple. Available in models for 1-, 3-, 4- and 6-channel models. ★Voltage check panel, "Type 260," is optional. —*Owen Laboratories, 55 Beacon Pl., Pasadena, Calif.*

For more information circle **288** on inquiry card

TRANSISTORIZED SUPPLIES

New semi-conductor transistor-regulated dc power supplies for low- and medium-voltage applications, feature

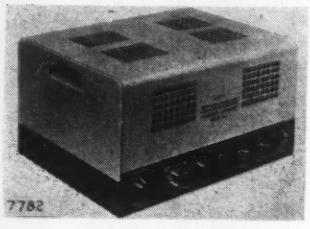


high conversion efficiency, low heat dissipation, small size, light weight, instant warm-up time, non-microphonic operation, fast transient response, and continuously-adjustable output. —*Electronic Research Associates, Inc., 67 E. Centre St., Nutley 10, N. J.*

For more information circle **289** on inquiry card.

FREQUENCY CONVERTER

New "Model 400A" is an improved low-cost light-weight (60-lb) model delivering 100 va of 400-cps power (variable from 380 to 420). Voltage regulation, no-load to full-load, is 0.25%; frequency regulation, no load to full load, is better than ±1 cps; total harmonic distortion is better than 3% and all three are indepen-



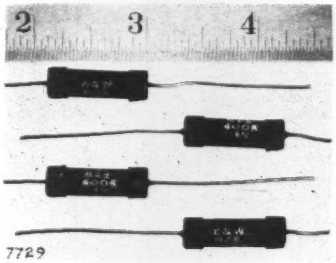
dent of power factor. Output amplitude is continuously variable from 90 to 130 v. Use of external capacitors increases variable frequency range from 200 to 1700 cps.—*Tel-Instrument Electronics Corp., 717 Garden St., Carlstadt, N. J.*

For more information circle **290** on inquiry card.

FIXED RESISTORS

FILM-ON-GLASS RESISTORS

New "Type N" 1%-tolerance precision film-type glass resistors have maximum resistance values increased



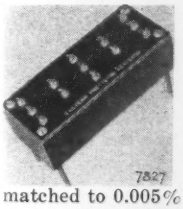
7729

by a factor of 10: 1-watt size from 40 to 400 kilohm and 2-watt size from 0.1 to 1 megohm. Temperature coefficients on improved resistors have been reduced from 500 to 300 ppm/°C. Other basic characteristics conform to MIL-R-10509B. Rated power is based on 40°C ambient temperature (derated linearly to 0 at 140°C).—*Corning Glass Works, Corning, N. Y.*

For more information circle **291** on inquiry card.

VOLTAGE-DIVIDING RESISTORS

PRECISION VD NETWORK


7827

New precision voltage divider is a network of eleven precision wire-bound resistors of values ranging from about 7000 ohms to 171,000 ohms matched to 0.005% at both dc and 400 cps over a temperature range of 50°C, mounted on an anodized engraved aluminum face plate containing Teflon feed-throughs to minimize leakage; four studs for mounting; then encapsulated in thermosetting resin with zero percent shrinkage. Meets MIL-R-93.—*Eastern Precision Resistor Corp., 675 Barbey St., Brooklyn 7, N.Y.*

For more information circle **292** on inquiry card.

TRIMMER VDRs

New "Type 101A" cylinder mount and "101B" bushing mount voltage-dividing resistors retain original features but cover a wider scope of applications; use 20 PPM resistance

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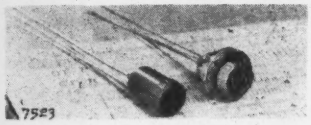
NEW INSTRUMENTS

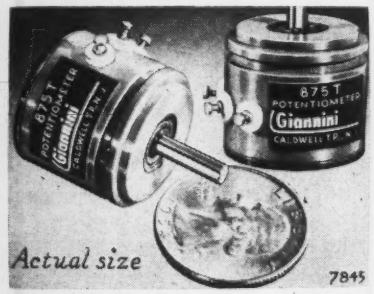


wire exclusively. Resistance range has been expanded to cover from 100 to 15,000 ohms. Ambient temperature range has been extended to permit ¼ watt power rating up to 87.5°C, above which it is linearly derated to zero at 150°C (1/10 watt at 125°C). New units withstand 30-*G* shock, will pass rigid humidity, salt spray and vibration requirements.—*Carter Mfg. Corp., 23 Washington St., Hudson, Mass.*

For more information circle **293** on inquiry card.

HIGH-TEMPERATURE VDR

New "Model 875T" servo-mount subminiature single-turn voltage-dividing resistor is rated to 200°C (2

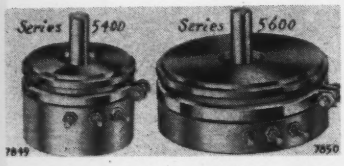


watts at 150°C); linearity 0.5% or better; resolution as high as 0.06%. Precious metals in coil and wiper for low contact pressure and long noise-free life. Up to six sections can be ganged.—*G. M. Giannini & Co., 918 E. Green St., Pasadena 1, Calif.*

For more information circle **294** on inquiry card.

PRECISION VDRs

New $1\frac{7}{8}$"-dia "Series 5400 Helipot," developed to fit A.I.A. dimensional standards, is housed in a dimension-

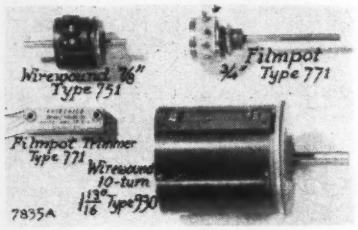


ally stable one-piece plastic cup; is a single-turn continuous-rotation unit which can have 8 sections ganged on a common shaft at factory, each with a maximum of 12 taps. Resistances from 25 to 51,000 ohms; linearity tolerance to 0.15% at 10,000 ohms and above. ★New 2" dia "Series 5600 Helipot" can have up to 8 sections on a common shaft with as many as 21 taps to a section.—*Helipot Corp., Newport Beach, Calif.*

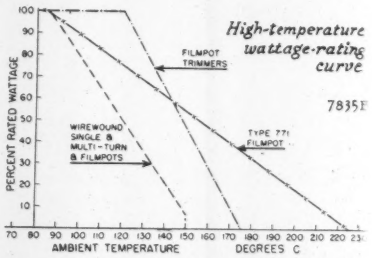
For more information circle **295** on inquiry card.

HIGH-TEMPERATURE VDRs

New complete line of high-temperature precision voltage-dividing resistors and components that have op-



erating temperatures from −55°C to 150°C, 175°C, or 225°C includes wire wound units in single and multi-turn

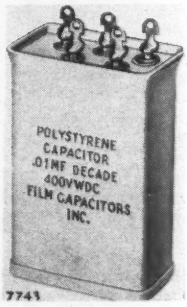


types; also rotary "FilmPots" and "Trimmer FilmPots" with exclusive "Nobl-Ohm" precious-metal-alloy film resistance element. New units have a hi-temp load life in excess of 500 hr and a hi-temp rotational life up to 500,000 cycles or equivalent for multi-turn units, depending upon resistance requirements.—*Fairchild Controls Corp., Components Div., 225 Park Ave., Hicksville, L. I., N. Y.*

For more information circle **296** on inquiry card.

CAPACITORS

DECADE CAPACITORS



New polystyrene and Teflon decade capacitors with accuracies to 0.5% and a rating of 400 vwdc are said to be ideal for use in test equipment and as standard for bridge setups. All units are stabilized to remain within 0.1% of their original values for 12 to 24 months. Available: 0.001, 0.01, 0.1 and 1.0 uf per step.—*Film Capacitors, Inc., 3400 Park Ave., New York, N. Y.*

For more information circle **297** on inquiry card.

SUBMINIATURE TANTALUM CAPACITORS

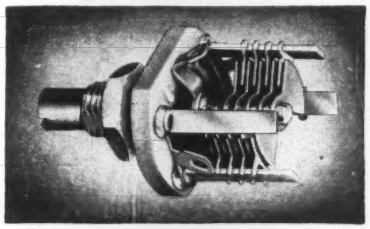
New "Type TNT" subminiature tantalum electrolytic capacitors feature "high ratings never before possi-

ble in such small physical size." Five ratings available: 80 mfd at 3 v; 50 mfd at 6 v; 25 mfd at 15 v; 15 mfd at 30 v; and 8 mfd at 50 v.—P. R. *Mallory & Co., Inc., Indianapolis 6, Indiana.*

For more information circle **298** on inquiry card.

BUTTERFLY CAPACITOR

New "Type MACBF" miniaturized variable capacitor of butterfly design providing extremely low capacitance

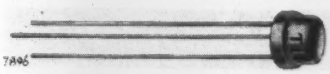


in VHF range can be either panel- or chassis-mounted by means of a threaded bushing with flatted sides. Standard models are available in 7, 9, 15 and 21 plates per section, with nominal values per section from 1.3 to 10.8 mmf.—*Hammarlund Mfg. Co., Inc., 460 W. 34th St., New York 1, N. Y.*

For more information circle **299** on inquiry card.

MILITARY TYPE TRANSISTOR

New "2N200" military type germanium *p-n-p* junction transistor, tested for operation up to 75°C, also



features 100% inspections for shock, vibration and moisture resistance; has a typical common emitter current gain of 45 and can dissipate up to 350 mw; has low noise figure.—*Transitron Electronic Corp., Melrose, Mass.*

For more information circle **300** on inquiry card.

TRANSISTOR TRANSFORMERS

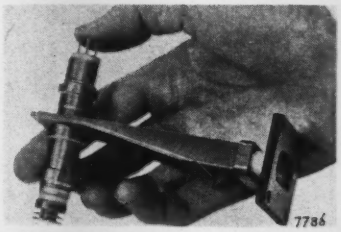
New series of input, output and interstage transformers for transistor circuit applications, feature ex-

tremely small size, high-efficiency nickel-alloy cores, bobbin-wound windings and flexible coded leads. —*Merit Coil Products Co., Inc., 4427 N. Clark St., Chicago, Ill.*

For more information circle **301** on inquiry card.

BACKWARD WAVE OSCILLATOR

New "Model VA-161" miniature backward wave oscillator, first of its kind, combines low power require-

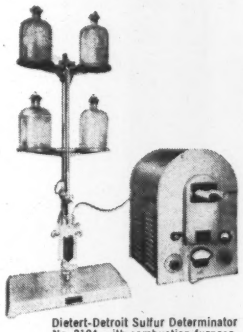


ments, small size and light weight with rugged construction; is instantaneously tuned by changing voltage; operates over normal 8.5 to 9.6 kMc radar band on less than 300 v, enabling use of existing radar system power supplies. Its permanent magnet weighs less than 5lb, obviating need for an electromagnet and its associated power supply.—*Varian Associates, 611 Hansen Way, Palo Alto, Calif.*

For more information circle **302** on inquiry card.

COAXIAL SLOTTED LINE AND BROADBAND PROBE

New 'Model SL-42" precision coaxial slotted line provides a means of making accurate VSWR and imped-



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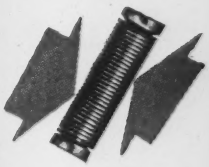
For more information circle **97** on inquiry card.

BRIDGEPORT BELLOWS SAVE SPACE



For miniaturization and weight reduction in instruments, aircraft and similar applications, Bridgeport small diameter bellows offer many new design opportunities. Seamless metal bellows in ¼" and 5/16" diameters are available from Bridgeport Thermostat in a wide range of characteristics and metals. Other sizes up to 5⅞" O.D.

Robertshaw-Fulton CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION
DEPT. (RL-125), MILFORD, CONNECTICUT

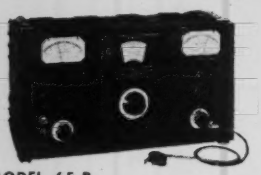
☐ Send data on small-diameter bellows
☐ Send Bellows Engineering Bulletin

NAME_____
COMPANY_____
ADDRESS_____
CITY_____ STATE_____

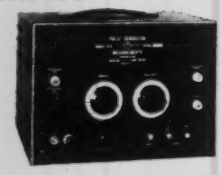
For more information circle **98** on inquiry card.

Laboratory Standards

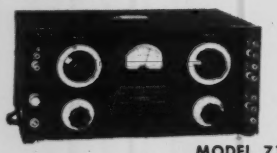
MEASUREMENTS CORPORATION



MODEL 65-B



MODEL 79-B



MODEL 71

STANDARD SIGNAL GENERATORS

MODEL	FREQUENCY RANGE	OUTPUT RANGE
65-B	75 Kc.-30 Mc.	0.1 microvolt to 2.2 volts
80	2 Mc.-400 Mc.	0.1 to 100,000 microvolts
80-R	5 Mc.-475 Mc.	0.1 to 100,000 microvolts
82	20 cycles to 200 Kc. 80 Kc. to 50 Mc.	0-50 volts 0.1 microvolt to 1 volt
84-TVR	400 Mc.-1000 Mc.	0.1 microvolt to 0.5 volt
84	300 Mc.-1000 Mc.	0.1 to 100,000 microvolts

SQUARE WAVE GENERATOR

MODEL	FREQUENCY RANGE	WAVE SHAPE
71	Continuously variable 6 to 100,000 cycles	Rise time less than 0.2 microseconds

PULSE GENERATOR

MODEL	REPETITION RATE	PULSE WIDTH
79-B	60 to 100,000 pulses per second	Continuously variable from 0.5 to 40 microseconds

VACUUM TUBE VOLTMETERS

MODEL	VOLTAGE RANGE	FREQUENCY RANGE
62	0-1, 0-3, 0-10, 0-30 0-100 volts AC or DC	30 cycles to over 150 Mc.
67	.0005 to 300 volts peak-to-peak	5 to 100,000 sine-wave cycles per second

MEGACYCLE METERS

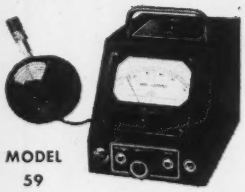
MODEL	FREQUENCY RANGE	FREQUENCY ACCURACY
59 LF	0.1 Mc. to 4.5 Mc.	Within ± 2%
59	2.2 Mc. to 420 Mc.	
59 UHF	420 Mc. to 940 Mc.	

CRYSTAL CALIBRATORS

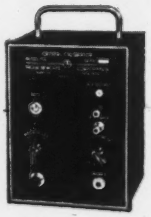
MODEL	FREQUENCY RANGE	FREQUENCY ACCURACY
111	250 Kc.-1000 Mc.	± 0.002%
111-B	100 Kc.-1000 Mc.	

MODEL 62

MODEL 59



MODEL 111



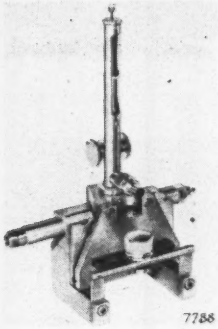
STANDARD TEST SET for TRANSISTORS MODEL 505

Tests PNP and NPN small-signal, medium-power and switching transistors.
Checks for short-circuited emitter-collector junctions.
Measures collector-to-emitter leakage current.
Measures collector current and d-c gain.
Case Dimensions: 10" high x 14" wide x 7¼" deep.
Power Supply: Two F4BP 6-volt dry batteries.
Weight: Approximately 9 pounds without batteries.

Measurements Corporation
BOONTON, N. J.

For more infomation circle **99** on inquiry card.

NEW INSTRUMENTS



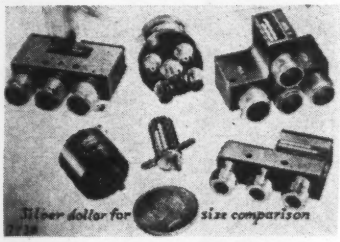
7788

ance measurements in the S, C and X bands to assist in eliminating transmission line mismatches and to determine antenna reflection characteristics. ★Completely tunable "Model PR-25" broadband probe greatly facilitates L, S, C and X band precision measurements.—*Vectron, Inc.*, 1571 *Trapelo Road, Waltham* 54, *Mass.*

For more information circle **303** on inquiry card.

COAXIAL SWITCHES

New series of broadband miniature and subminiature coaxial switches, for applications in all types of RF instal-

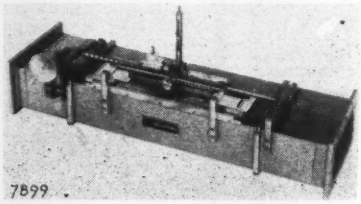


lations in frequencies up to X band, are said to be "the lightest, smallest co-axial switches now made," also feature low operating power (0.1 amp maximum at 26 vdc); are available in sp-4t, sp-3t, sp-2t, dp-2t, dp-3t (fail-safe or selective) in types HN, N, C, BNC, and subminiature series 27 connectors; meet environmental requirements of MIL-E-5272a.—*Electromation Co., Cado Div.*, 116 *S. Hollywood Way, Burbank, Calif.*

For more information circle **304** on inquiry card.

L-BAND SLOTTED LINE

"Model SL-28 L-Band Slotted Line" is said to be an extremely rugged and stable instrument for accurate meas-



7899

urement of magnitude and phase of voltage standing-wave-ratio in standard L-band waveguides at frequencies

VALVES

BASIC CONTROL COMPONENTS

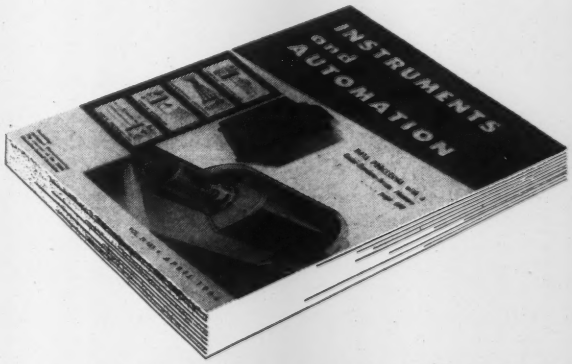
"Valves are used at every stage of the production, distribution, storage, and pressure control of the water you drink, the chemicals used in industry, the gasoline in your car, the steam in your boiler house, the gas in your kitchen stove, etc., etc."*

Yes, valves are basic industrial components, but their sale is nonetheless dependent on *promotion* to the prospective user-buyer.

These valve manufacturers advertise in *Instruments and Automation*—the basic valve advertising medium for the control field:

Annin Company
Askania Regulator Company
Automatic Switch Company
Automatic Temperature Control Company
Bailey Meter Company
Baldwin-Lima-Hamilton Corporation
Barber-Colman Company
Barksdale Valves
Black, Sivalls & Bryson, Inc.
Bristol Company
Brooks Rotameter Company
Brown Instrument Div., Minneapolis-Honeywell Regulator Company
Conoflow Corporation
R. W. Cramer & Co., Inc.
G. W. Dahl Co., Inc.
Doelcam Div., Minneapolis-Honeywell Regulator Company
Edison Instrument Div., Thomas A. Edison, Inc.
Electric Indicator Company
Farris Engineering Company
Fisher Governor Company
Ford Instrument Div., Sperry-Rand Corp.
Foxboro Company
Claud S. Gordon Company
Hagan Corporation
Hammel-Dahl Company
Hoke, Inc.
Imperial Brass Mfg. Co.
Industrial Engineering Corporation
Jerguson Gage & Valve Company
Leeds & Northrup Company
Leslie Company
Magnatrol Valve Corporation
Manning, Maxwell & Moore, Inc.
Marsh Corporation, Jas. P.
Midwestern Instruments
Moog Valve Company
North American Instruments, Inc.
Panellit, Inc.
Parker Appliance Company
Powers Regulator Company
Republic Manufacturing Company
Robertshaw-Fulton Controls Company
Rockwell Manufacturing Company
S. Morgan Smith Company
Swartwout Company
Vapor Recovery Systems Company
Waukee Engineering Company
Western Gear Corporation
Weston Electrical Instrument Corp.

For your valve and other process control equipment advertising, use the basic medium in the field . . .



845 Ridge Avenue, Pittsburgh 12, Pa.

* From a series of articles on "Control Valves," by C. S. Beard, currently running in *Instruments and Automation*.

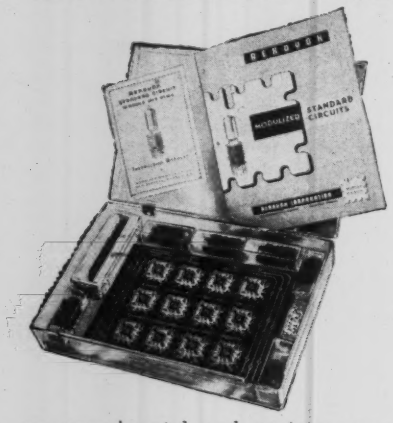
from 1120 Mc to 1700 Mc. Residual VSWR less than 1.05 with probe in position; negligible slope and leakage. ★ Accessory "Model A-10 Waveguide to Coaxial Adapter Connector" provides efficient transition between L-band waveguide and ⅜" (Type N) coaxial line.—*Vectron, Inc.*, 1571 *Trapelo Road, Waltham* 54, *Mass.*

For more information circle **305** on inquiry card.

ELECTROMECHANICAL COMPONENTS

STANDARD-CIRCUIT MODULES AND BREADBOARD KIT

New standard-circuit modules and handy breadboard simplify and speed

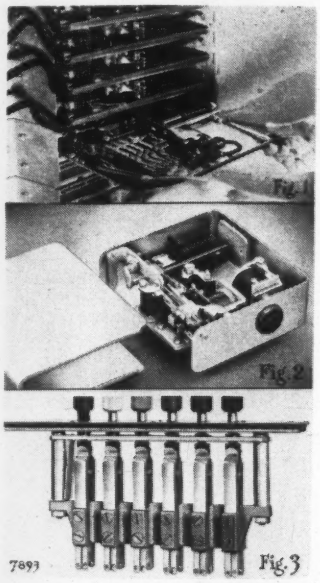


up experimental and prototype assemblies. Modules are commercialized version of original "Project Tinkertoy"; are available in seven circuits or block diagrams, each including necessary components on stacked wafers wired together by riser conductors and provided with base prongs for plugging into socket. Kit comprises seven standard-circuit modules, one 12-position module breadboard, 50 banana plugs.—*Aerovox Corp., New Bedford, Mass.*

For more information circle **306** on inquiry card.

INDUSTRIAL SWITCHES

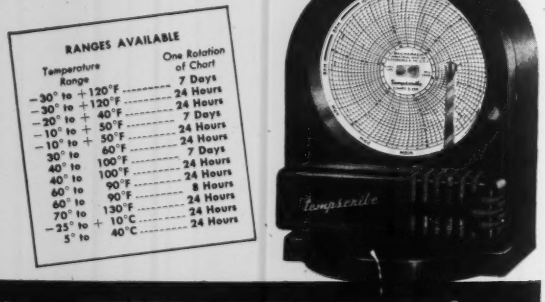
Newly available for industrial applications are two general types: automatic-stepping, and manual-operation key. Principal among stepping switches is "XY Universal Switch" (Fig. 1), a two-motion 100-point step-by-step switch operating over 10 points in each of two directions, which can be used to search through 100 four-wire circuits to find a particular circuit, to select a particular circuit from among 100 circuits, or to perform consecutive operations in 100 separate circuits. Similar but smaller is "XY Deca Switch" (Fig. 2) providing 10-point selection among 10 four-wire circuits. Among key switches are many cam key, indicating, plunger, push and twist button types, with locking and interlocking features



if desired (Fig. 3). Suitable mountings for single or multiple key arrangements of any type are available. —*Telephone Div., Stromberg-Carlson Co., Rochester* 3, *N. Y.*

For more information circle **307** on inquiry card.

For Accurate TEMPERATURE RECORDS at MODERATE COST


RANGES AVAILABLE
Temperature Range
One Rotation of Chart
−30° to +120°F 7 Days
−30° to +120°F 24 Hours
−20° to + 40°F 24 Hours
−10° to + 50°F 7 Days
−10° to + 50°F 24 Hours
30° to 60°F 24 Hours
40° to 100°F 7 Days
40° to 100°F 24 Hours
60° to 90°F 8 Hours
60° to 90°F 24 Hours
70° to 130°F 24 Hours
−25° to + 10°C 24 Hours
5° to 40°C 24 Hours
Tempscribe

Use TEMPSCRIBE Recorders

The TEMPSCRIBE self-registering Recording Thermometer meets a long-felt need for a moderately priced recorder for general purpose applications where a graphic record of temperature in surrounding air is required. The record—written on an easy-to-read chart, 4" in diameter, with graduations spaced uniformly over full range—is indispensable wherever knowledge is desired if temperature goes above or below any given point. TEMPSCRIBE is the only recorder made with pen and actuating element in door, which, when opened, permits a clear view of the complete chart, and easy chart replacement without danger of damaging pen arm or accidentally marking chart.

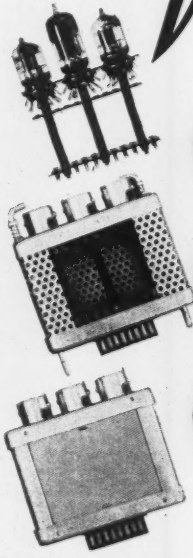
Write for Bulletin 704

BACHARACH INDUSTRIAL INSTRUMENT CO.
7301 Penn Avenue • Pittsburgh 8, Pa. T-13r

For more information circle **100** on inquiry card.

Unitize—Miniaturize

WITH *Vector* STRUCTURES FOR CIRCUITRY



TAKE ONE STRIP TURRET

Choice of Deck, or Wall type strips in many sizes offers miniaturization, accessibility, ease of assembly and adaptation to semi-automatic machinery.

ASSEMBLE IN LIP-LOC CASE

A sectionalized case with a choice of plugs, quarter turn locks, ventilated or solid wall; with two piece center section or snap-open side ports.

***Result* PLUG IN UNIT**

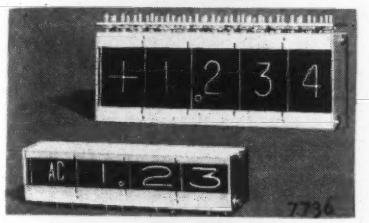
For circuit unitization, faster final assembly, stock reduction and ease of equipment maintenance.

VECTOR ELECTRONIC COMPANY
3352 San Fernando Road, Los Angeles 65, Calif.
Telephone CLinton 7-8237

For more information circle **101** on inquiry card.

DIGITAL READ-OUTS

New models of maker's true digital in-line read-outs have been improved by development of a connector

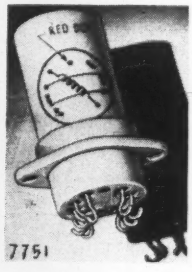


which makes bulb changing easier: lead is soldered to connector, not to bulb base. Connectors are spring-loaded to insure good contact with base.—*Electro Instruments, Inc.*, 3794 *Rosecrans Ave., San Diego* 10, *Calif.*

For more information circle **308** on inquiry card.

SUBMINIATURE AC RELAY

New "HG-2SM-R" ac relay retains all the characteristics of maker's "HG-2-SM" dc relay but will operate at dc to 10 kc. Operating voltages 6 to 115 v ac or dc. Capable of operation up to 140°C, unit exceeds MIL-R-5757C. Contact ratings 3 amp resistive and 1 amp inductive at 28 vdc or 115 vac.—*HI-G, Inc., Bradley Field, Windsor Locks, Conn.*



For more information circle **309** on inquiry card.

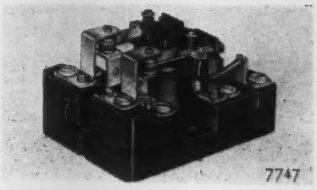
TIME DELAY RELAY

New "Snapper" thermal time delay relay is for delaying application of high voltage until after warm-up, for over- and under-voltage protection with simultaneous fault indication, etc.; has sp-dt contact action, high ambient temperature range and freedom from chatter and arcing. Factory preset time delays in metal from 3 to 120 sec, in glass 5 to 60 sec. Units are available in metal envelope, miniature (7- and 9-pin) or octal (8-pin), and in a glass envelope in 9-in pin only.—*Curtiss-Wright Corp., Wood-Ridge, N. J.*

For more information circle **310** on inquiry card.

POWER RELAY

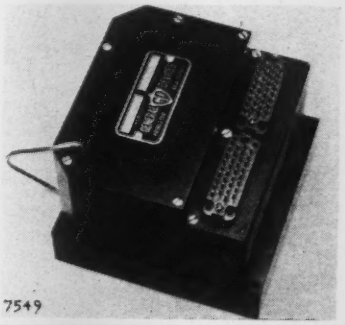
New 25-amp heavy-duty power relay is said to have electrical characteristics equivalent to or even greater than those of bulkier devices; is designed to meet UL specs. Unique "interchangeable coil" feature: by removing two screws, coil assembly can be removed and replaced in a few minutes.—*Guardian Electric Mfg. Co., 1621 West Walnut St., Chicago* 12, *Ill.*



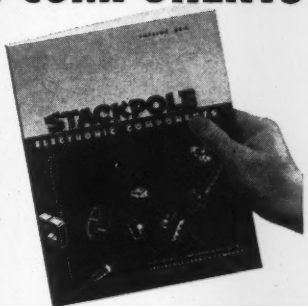
For more information circle **311** on inquiry card.

SAMPLING SWITCHES

New series of rugged 3-pole 60-contact sampling switches featuring 5-minute brush replacement do not



Write for this 56-page GUIDE to STACKPOLE ELECTRONIC COMPONENTS



• **FIXED RESISTORS**
½, 1 and 2-watt types for every industrial and military use.

• **VARIABLE RESISTORS**
Volume, tone controls, potentiometers, etc.

• **POWDERED IRON CORES**

• **CERAMAG® Ferromagnetic CORES** **MOLDED COIL FORMS**

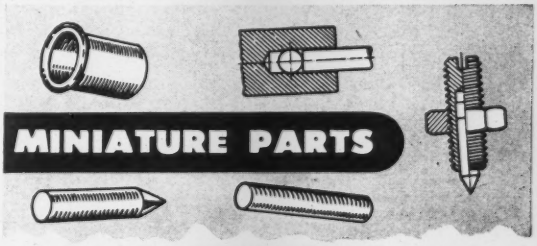
• **INEXPENSIVE SLIDE SWITCHES**

• **GA CAPACITORS**

• **CERATAB® PRINTED CIRCUITS**

Electronic Components Division
STACKPOLE CARBON CO., St. Marys, Pa.

For more information circle **102** on inquiry card.



CUSTOM MANUFACTURE of SMALL PARTS

Instrument Pivots
- As separate items or mounted in components—special steel, heat treated for maximum hardness, polished, metallographic finish. To specifications up to ⅜" diameter.

Shafts and Staffs
- Burrless, plain or alloy steel, heat treated to specifications. Metallographic finish.
- Tubular Products up to ⅜" Diameter, Cut, Flared, Swaged, Formed and Burr-Free. Alloy or Silver Plated.
- Screw-Machine Products up to ¾" Diameter.

SERVICES FOR CUSTOMERS' PARTS
- A Multitude of Services are Available for Customers' Parts at Any Stage of Manufacture. These Include: Controlled-Atmosphere Heat-Treating, Centerless Grinding, Surface Grinding, Special Facilities for Ceramic Rods and Shapes, Knurling, Thread-Rolling to close tolerances, Swaging, Drilling, Milling, Burr Removing, Metallographic Polishing, Barrel-Plating in Alloy or Silver, light Punch-Press Work.

SPECIALTIES
- "Welton" noncorrosive paste solder for hairsprings or similar soldering.
- "Wentonoil" treated bottonwood pith for lubricating instrument pivots.

APPARATUS DESIGN SERVICES
- In Connection with the Design and Fabrication of Precision Miniature Parts.

ENGINEERING ASSISTANCE ON ALL ITEMS

Welton V. Johnson ENGINEERING COMPANY INC
92 SUMMIT AVENUE • SUMMIT N J

For more information circle **103** on inquiry card.

AEMCO

RELAYS
are standouts for performance
... built to last!

One of today's most versatile relay lines, AEMCO relays are "first choice" for more than 100 of the top names in American industry. Design and construction is tops—for only the finest materials are used in AEMCO relays. Specify AEMCO and you're making your best relay buy. You'll profit by the newest production techniques that speed up delivery and save you money. You'll appreciate the prompt delivery on prototypes, the fast tool up for production. You'll find, too, that an AEMCO relay has more lives than a cat and is built to take it! Actually tested on the job, AEMCO relays are dependable and reliable . . . standouts for performance.

AEMCO relays are available in a wide variety of spring and coil combinations, operating potentials and contact ratings. Types include: Open, can, plug-in base, hermetically sealed, midgets, dual-purpose, delayed make or break, circuit control, current and potential relays. Should one of the hundreds of AEMCO relay types fail to meet your exact requirements, we will be happy to design and build a unit to meet or exceed your specifications.

WRITE TODAY
For more information on the standard AEMCO relay line, write for your free descriptive bulletin today!

AEMCO
AUTOMATIC ELECTRIC MFG. CO.
53 STATE ST. • MANKATO, MINNESOTA

For more information circle **104** on inquiry card.

NEW INSTRUMENTS

require force or phase adjustments; come complete with 6, 12, or 28 vdc motor, shielded RF filter, special precision spur gear reduction. Also available with speed governor.—*General Devices Inc., Princeton, N. J.*

For more information circle **312** on inquiry card.

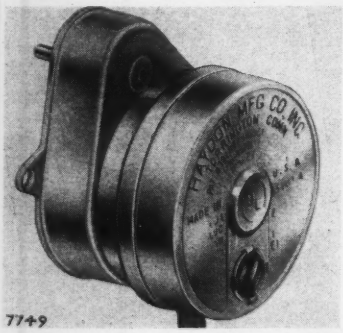
MOMENTARY CONTACT SWITCH

New "No. 29" single-circuit momentary-contact switch featuring a normally ON is recommended for automatic control of lights, as in door openings; is rated 0.75 amps at 125 vac; is UL inspected and approved.—*McGill Mfg. Co., Inc., Valparaiso, Ind.*

For more information circle **313** on inquiry card.

HYSTERESIS TIMING MOTOR

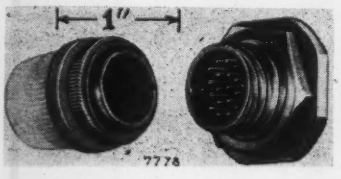
New "Series A2334" synchronous timing motor develops 10 oz-in torque at 1 rpm while retaining advantages of hysteresis type motors. Speeds 1, 2, 4, 6, 8 and 10 rpm in right and left hand rotation; one-way and two-way frictions available; 115 or 230 60 cps. Minimum order 500 units; special shafts and pinions available to customers' requirements.—*Haydon Mfg. Co., Inc.*, 245 *East Elm St., Torrington, Conn.*



For more information circle **314** on inquiry card.

MINIATURE CONNECTOR

New "Pygmy" is available in both "A" and "E" styles; in a series for potting; with jam nut receptacles; and with hermetically-sealed recep-

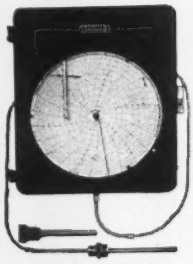


4½" DIAL THERMOMETERS

Made in 3 types to suit any requirements. Rigid stem, wall or flush mounted, 11 inches of scale reading. Interchangeable with standard industrial separable sockets. Stem can be placed at any angle and case can be rotated to any readable position.

PALMER
MERCURY ACTUATED
Temperature Indicating
Instruments

RECORDING THERMOMETERS



Twelve inch die-cast aluminum case with black or white wrinkle or satin finish. Single or multiple pen construction. Electric or spring wound clock, 24 hour or 7 Day Revolution. Flexible Armor and bulb of stainless steel. Ranges —40 +950°F or Equivalent in °C.

INDUSTRIAL THERMOMETERS

Red-Reading Mercury —Extruded brass case — chrome finish. Ranges —40 + 950°F or Equivalent in °C.

RED-READING MERCURY LABORATORY THERMOMETERS

Thoroughly annealed for permanent accuracy. Complete line A.S.T.M. and fractional division types.

Write For Catalog Information

PALMER
THERMOMETERS, INC.
Cincinnati 12 Ohio • MElrose 1500

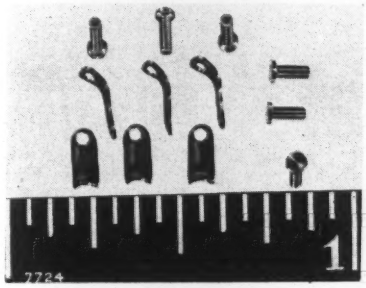
For more information circle **105** on inquiry card.

tacles; with a double-stub quick-action thread and a three-point bayonet lock; cadmium plate or alumilite finishes.—*Scintilla Div., Bendix Aviation Corp., Sidney, N. Y.*

For more information circle **315** on inquiry card.

MICROMINIATURE TERMINAL LUGS AND RIVETS

New terminal lugs and rivets are smaller than normal subminiature hardware. Lug is 24-carat-gold plated,



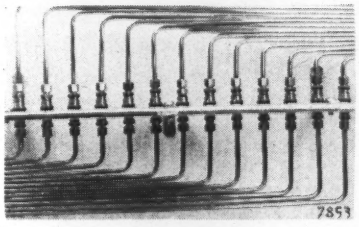
shot burnished, with a continuous convex curvature throughout its length for maximal pressure with spring tension against the rivet head. Rivet is also gold-plated. Both are non-magnetic. ★ Also available are tools for use in any press.—*Circon Component Co., Santa Barbara Municipal Airport, Goleta, Calif.*

For more information circle **316** on inquiry card.

MECHANICAL COMPONENTS

BULKHEAD BAR FOR TUBING TERMINAL CONNECTIONS

New bulkhead bar for straight or angled instrument tubing terminal connections is a light section of chan-

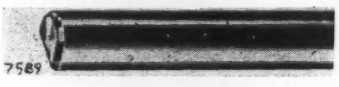


nel with ¼" brass couplings mounted on 1½" centers. Standard bar is 5-ft long and contains 40 couplings; others (like this one with 13 couplings) to order.—*Instrof Corp., Collegeville, Pa.*

For more information circle **317** on inquiry card.

SHAFT COMPONENTS

New stainless steel shafts accept all "Servoboard" parts. However, shaft diameter of electrical compo-



WEKSLER INSTRUMENTS

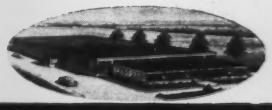
for INDICATING, RECORDING & CONTROLLING TEMPERATURE, PRESSURE AND HUMIDITY

Engineered for Precise Performance

The Weksler Thermometer Corp. specializes in the design and manufacture of precision instruments to accurately indicate, record and control temperature, pressure and humidity. Weksler offers the most complete range to choose from; there is a Weksler instrument to meet most special requirements.

With more than 30 years of experience in the field, American Industry turns to Weksler because . . ."You can rely on Weksler . . ."

Write for FREE Condensed Bulletin CB56 on Industrial Instruments. You are invited to take advantage of Weksler's Design, Development and Research Dept.



WEKSLER THERMOMETER CORPORATION
195 EAST MERRICK ROAD • Dep't. IN-57 • FREEPORT, L.I., N.Y.

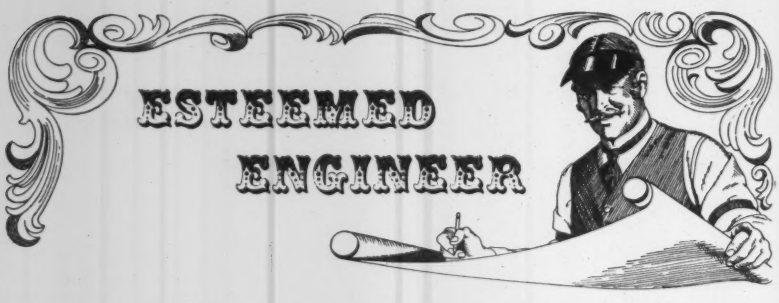
For more information circle **106** on inquiry card.

ANALOG COMPUTER ENGINEERS

. . . to operate and maintain a major analog computer facility at Lockheed's new Research Center at Palo Alto. The position requires a degree in Electrical Engineering and experience related to analog computers. Please address inquiries to M. H. Hodge of the Research and Engineering Staff at Sunnyvale, California

Lockheed

MISSILE SYSTEMS DIVISION
research & engineering staff
LOCKHEED AIRCRAFT CORPORATION
VAN NUYS · PALO ALTO · SUNNYVALE · CALIFORNIA



It is not our intention to insult your fine sense of critical judgment by flamboyant rhetoric designed to distract your penetrating appraisal of

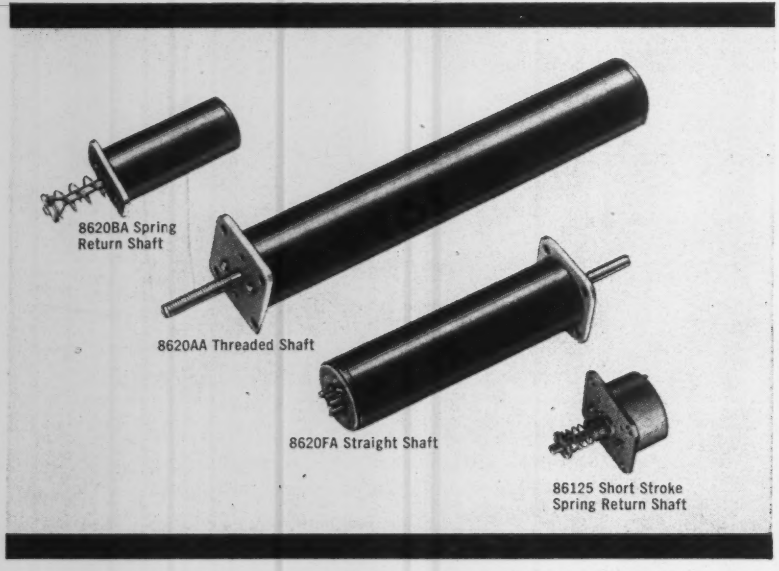
GIANNINI RECTIPOTS

However we do invite your kind attention to the meritorious qualities harbored within the protective instrument cases pictured below.

It is indeed through

Accuracy and Reliability

that the true qualities of Giannini precision rectilinear potentiometers are meaningfully apprehended.



Resistance Ranges—from 80 ohms to 75000 ohms per inch of stroke
Linearity—better than ±0.5% of total resistance
Resolution—as high as 0.001 inch
Shaft Displacement—from 0.1 inch to 5.0 inches

For full details write for Bulletins 8620 and 86125

Giannini *ELECTROMECHANICAL DIVISION*

G. M. GIANNINI & CO., INC. • 918 E. GREEN STREET • PASADENA, CALIF.

For more information circle **107** on inquiry card.

NEW INSTRUMENTS

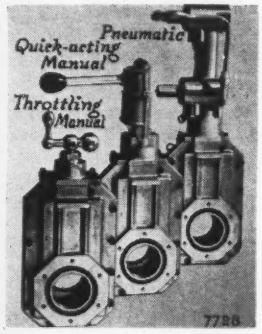
nents may differ from model to model. SS shaft adapters (adjusting almost all of electrical components accepted by maker's 14 standard component hangers) will "correct" components with certain shaft diameters. Also available: collars to prevent axial displacement of shafts not directly connected; shaft coupling; pin coupling.—*Servo Corp. of America*, 20-20 *Jericho Turnpike, New Hyde Park, L. I., N. Y.*

For more information circle **318** on inquiry card.

VALVES, etc.

HIGH-VACUUM GATE VALVES

New "SVT Series" high-vacuum straight-through gate valves, available in 2", 4", and 6" dia, are full-

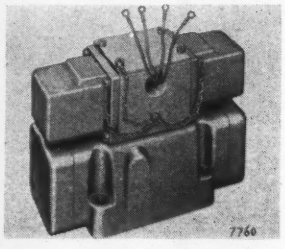


opening; have a short flow path for minimum impedance; will seal vacuum-tight in either direction; have drilled flanges with gasket grooves and gaskets on both sides, and action of mechanism is such that no scuffing of plate gasket is possible.—*Consolidated Electrodynamics Corp., Rochester Div.*, 1175 *Mt. Read Blvd., Rochester 3, New York.*

For more information circle **319** on inquiry card.

3000-lb HYDRAULIC VALVES

New "9700 Series" pilot-operated hydraulic control valves, designed to meet JIC specs, feature operating

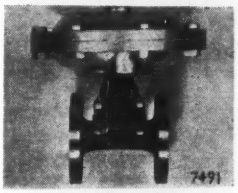


pressures to 3000 psi; continuous-duty solenoids; subplate mounting; intermediate choke block; spring return; open and closed center-type spools. Available in 2- and 3-position 4-way; 2-position 2 and 4-way. Sizes from ⅛" to 1¼".—*Logansport Machine Co., Inc., Logansport, Ind.*

For more information circle **320** on inquiry card.

SAUNDERS VALVE

New small-flow air-operated Saunders-type control valve with springless motor is available in ½" and ¾"

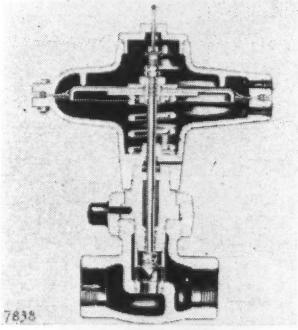


sizes (over-all height 6"). Screwed or flanged bodies of cast iron, stainless steel, rubber-lined, glass-lined, Hastelloy "C" and many other materials. New valves can be used for controlling high vacuum. Top-mounted Moore valve positioners available for throttling control.—*Uniflow Valve Corp., 19 Quine St., Cranford, N. J.*

For more information circle **321** on inquiry card.

FIELD CONTROL VALVE

New "Series 125P" diaphragm-motor control valve, designed for high-pressure oil production work (to 2000

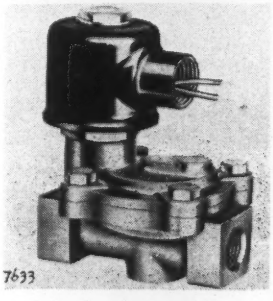


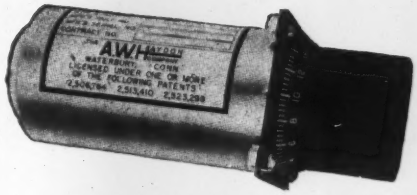
psi) is unusually small in size (largest size is less than 2 ft high over-all); features interchangeability of topworks on all body sizes and ease of reversing topwork action without additional parts; is available in 1" and 2" screwed sizes with angle or globe bodies, orifice sizes up to 1".—*Fisher Governor Co., Marshalltown, Iowa.*

For more information circle **322** on inquiry card.

DIAPHRAGM TYPE SOLENOID VALVE

New "K-181" diaphragm-type solenoid valve meets need for an "off-the-shelf" multi-purpose valve. With





precision components pay off in performance

THE A. W. HAYDON CO. SPECIAL TIME DELAY RELAY **never gives in to severe vibration, shock or sustained acceleration. Positive detent arrangement maintains time setting under all conditions. Large adjusting knob facilitates changing of time setting. Stepless clutch drive minimizes clutch error.**

SPECIFICATIONS

1.* **Voltage Range: 24-29 Volts DC at 68°F.**

2. **Accuracy over Calibrated Range of adjustment:**
   (a) **±0.1 second or ±1% of setting, under condition 1.***
   (b) **±0.15 second or ±2% of setting, over wide temperature range.**

3. **Meet Military Specs. for temperature, altitude, sand and dust, fungus, salt spray, radio filtering.**

4. **Vibration: 5-55CPS with total excursion 0.060".**

Current ratings at 29 Volts and room temperature:

1. **Motor— 25 Milliamps** 2. **Clutch— 200 Milliamps** 3. **Contacts— 1.0 Amp Inductive**

Time delay period can be adjusted in 2/10 second increments over range of 0.2—30 seconds. (Catalog on Request)

PREFERRED WHERE PERFORMANCE IS PARAMOUNT

The A. W. HAYDON Company
Design and Manufacture of Electro-Mechanical Timing Devices
228 NORTH ELM STREET WATERBURY 20, CONNECTICUT

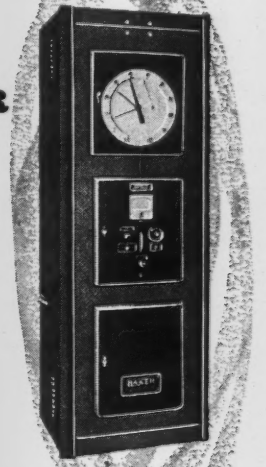
For more information circle **108** on inquiry card.

accurate indication of 0.0002% oxygen, 0.0004% hydrogen

with the

Super-Sensitive

DEOXO INDICATOR



The measurement range of this super-sensitive equipment is from 0.0002% to 0.0200% (2 to 200 parts per million) oxygen and from 0.0004% to 0.0400% hydrogen. A dual range permits measurement of up to 0.5% oxygen or 1.0% hydrogen.

OTHER OUTSTANDING FEATURES:

- **A self-contained calibrating unit and a recorder for a continuous, permanent record are included as integral parts of the unit.**
- **A recorder-controller can be supplied in place of the recorder, if desired.**

Write for additional data, technical assistance.

BAKER & COMPANY, INC. PRECIOUS METALS 113 Aster St., Newark 5, N. J.

ENGELHARD INDUSTRIES

NEW YORK • SAN FRANCISCO • LOS ANGELES • CHICAGO

For more information circle **109** on inquiry card.

BROOKS LEADERSHIP *achieved by design*

dowel-pins are the difference

NO TORQUE

NO LINE STRAIN

8 stainless steel dowel-pins precisely align the side plates and end fittings, are the keys to quick, trouble-free assembly and maintenance of the Brooks Full-View* Rotameter. The metering tube is installed after the frame is completely assembled. Tube breakage due to line strain and misalignment is thereby eliminated. It's as simple as placing a round peg in a round hole.

This feature, if considered alone, would make dowel-pin, side-plate construction your most important rotameter specification.

Send for Bulletin 115

*Trade-Name

TM

a complete line... **BROOKS**

ROTAMETERS *...for every service*

BROOKS ROTAMETER COMPANY

104 EIGHTH STREET • LANSDALE, PA.

For more information circle **110** on inquiry card.

NEW INSTRUMENTS

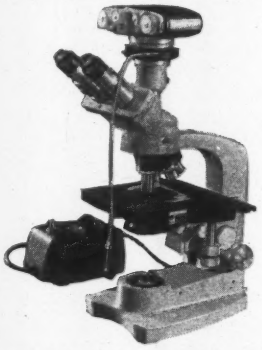
its full-flow ports it can handle large capacities with a minimum pressure drop, thus is suitable for shut-off control service up to 250 psi. Positive operation in any position. Available in ⅜" and ½" sizes.—*General Controls Co.*, 801 *Allen Ave., Glendale 1, Calif.*

For more information circle **323** on inquiry card.

OPTICS

INDUSTRIAL MICROSCOPES

New "Microstar" line of compound microscopes is completely new. Basic design (unique in U.S.) features in-

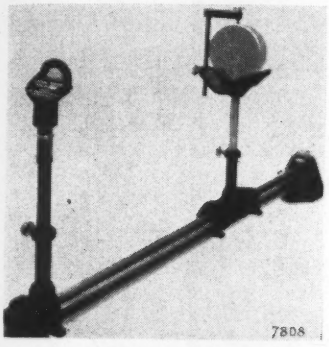


terchangeable and reversible inclined monocular, binocular and trinocular bodies. Variable autofocus minimizes possibility of damage to objective and specimen. Both left-hand and right-hand mechanical stages are available. All major adjustments are located in substage zone for ease of manipulation. Many models available to meet specific needs.—*American Optical Co., Instrument Div., Buffalo 15, N. Y.*

For more information circle **324** on inquiry card.

OPTICAL TESTER

New model of Optical Tester can be mounted on optical benches for testing lenses and mirrors for focal

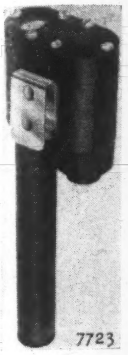


length, aberrations, and accuracy of optical figure; yields a fringe pattern which reveals quality of element. —*Ann Arbor Optical Co., P. O. Box 2056, Ann Arbor, Mich.*

For more information circle **325** on inquiry card.

NUCLEONICS

DOSIMETER

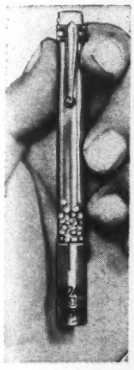


New "Radiac Set" embodies an indicating quartz-fiber dosimeter and a friction-type electrostatic charger which requires no batteries and operates under extreme environmental conditions. A unique voltage regulator prevents excessive overcharging of dosimeter. Entire combination can be comfortably worn, by clip, in a pocket or on belt; is available in ranges from 200 milliroentgens to 600 roentgens. All models meet MIL and CD specs for accuracy, spectral response, leakage, temperature, immersion, vibration and shock.—*Chatham Electronics Div., Gera Corp., Livingston, N. J.*

For more information circle **326** on inquiry card.

DOSIMETER

New "Radad" dosimeter is claimed to provide "both cumulative measurement and instantaneous reading of dangerous amounts of exposure to gamma rays," is a self-contained sealed ionization chamber containing polystyrene indicating beads (which are electrostatically charged by shaking the tube). When dosage approaches limit, beads lose their charge and drop to bottom of chamber, out of sight below metal ferrule. Dosimeter is recharged by shaking. Two models: "523F" calibrated to detect 50 roentgens exposure, and "523M" to detect 25 r.—*Pacific Transducer Corp., 11836 W. Pico Blvd., Los Angeles 64, Calif.*



For more information circle **327** on inquiry card.

SCINTILLATION DETECTOR

New "Model DS-3A Scintillation Well Counter," for measurement of gamma-emitting radioactive samples,

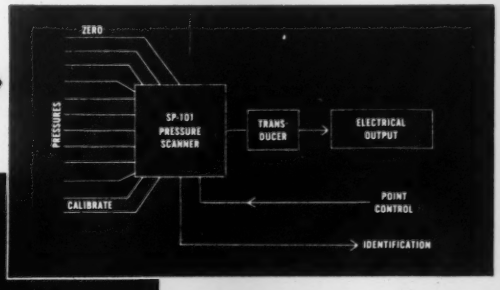
the New DATEX PRESSURE SCANNER*

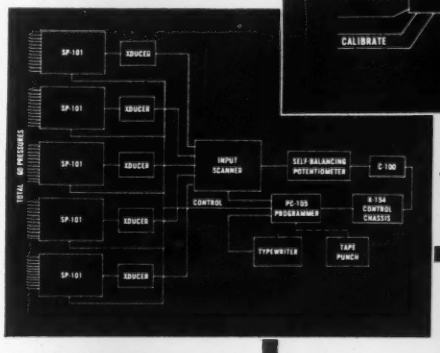
Multiple Pressures with ONE transducer

Designed to permit the measurement of up to 12 pressure sources with only one transducer, the DATEX Pressure Scanner introduces a new concept into pressure instrumentation. As illustrated, this device can be used to introduce calibration and/or zero pressures to check the operation of the system during each cycle. Provides complete flexibility in programming for Digital applications; i.e. positive positioning allows points to be skipped or scanned in any desired sequence by remote control. The transducer is vented to atmosphere between pressure ports, thus eliminating transducer hysteresis effects.

Basically, the SP-101 consists of a stator having 12 input ports, and a rotor that connects any one of the twelve input ports to an output port. The rotor is rotated to a desired position by a unidirectional high-torque motor, whose operation is controlled by means of a positive positioning arrangement. A relay circuit is incorporated in the unit to provide dynamic braking in order to stop the motor in a position where the rotor and stator ports are in coincidence. Two additional banks of contacts are provided on the internal switch so that indication of the rotor position can be obtained either visually (lights) or digitally for operation of recording devices.

TYPICAL SYSTEM USING ONE TRANSDUCER





TYPICAL DATEX DIGITAL DATA SYSTEM FOR RECORDING 60 PRESSURES

*MANUFACTURED UNDER LICENSE FROM UNITED AIRCRAFT CORP

SPECIFICATIONS

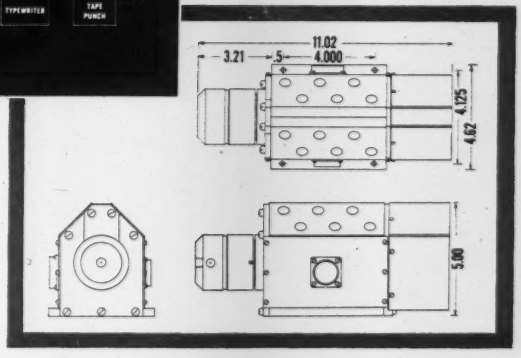
FLUIDS:
Air and non-corrosive dry gases

PRESSURES:
From 0.1 psia to 350 psig

POWER:
50 watts, 115V a-c, 60 cycle

CONNECTIONS:
Input and Output–⅛" NPT

POSITIONS: 12
Designed for bulkhead mounting.



Additional detailed information can be obtained by writing to:

GIANNINI DATEX DIVISION

1307 South Myrtle Avenue, Monrovia, California

G. M. GIANNINI & CO., INC. 918 EAST GREEN STREET • PASADENA, CALIFORNIA

For more information circle **111** on inquiry card.

features a large sodium iodide "well" crystal which accommodates a test tube or centrifuge tube containing sample. Excellent counting geometry provided by "well" permits rapid measurements and enables user to obtain highest statistical accuracy with least amounts of radioactivity. Device's exclusive electronic preamplifier circuit permits its use with gamma-ray spectrometer systems.—*Nuclear Instrument & Chemical Corp., 229 W. Erie St., Chicago 10, Ill.*

For more information circle **328** on inquiry card.

TRANSISTORIZED SCALERS

New "Transcaler" completely transistorized scalers, for laboratory and field use, range from a basic scale-of-128 unit to decade scalers with counting rates of 1 Mc; include automatic count-down circuitry and other features found in elaborate tube models. "Model 7002 A," basic model of series, features 100-kc counting rate, a mechanical totalizer, manual selection of input pulse polarity, option of battery pack operation or built-in power supply for ac line operation, pulse pair resolution of better than 10 usec and output pulse rise time of less than 0.5 usec.—*La Roe Instruments, Inc., P. O. Box 5906, Bethesda 14, Md.*

For full details, write directly to manufacturer.

SAMPLE CHANGER

New "Automatic Radioassay Systems" are claimed to "set a new record for speed, capacity and convenience in counting and recording data on large numbers of radioactive samples to guard atomic workers from radiation hazard." Unattended two-detector sample changer rapidly measures and prints out radioactivity present in up to 250 samples from air filters, benchtops and floors.—*Dep't 4047, Beckman Instruments, Inc., Berkeley Div., 2200 Wright Ave., Richmond 3, Calif.*

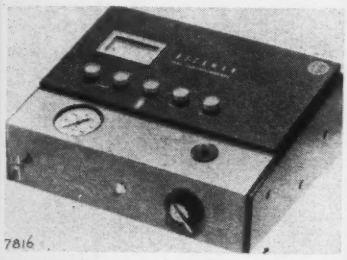
7718

For more information circle **329** on inquiry card.

LABORATORY EQUIPMENT

GAS CHROMATOGRAPH

New Gas Chromatograph, designed especially for analysis of gases and low-boiling liquids, is said to give accuracies equalling even highest-priced gas chromatography instruments for materials of BP not above 80°C; has provision for connecting a self-balancing potentiometer recorder with 1-second response for permanent recordings of sample volume. —*Scientific Instruments Div., Beckman Instruments, Inc., Fullerton, Calif.*



7816

For more information circle **330** on inquiry card.

GAS CHROMATOGRAPHY APPARATUS

New "Universal Model K-3" of maker's "Kromo-Tog," for gas and vapor-phase chromatography, is smaller (24" high) and lower-priced than

BARBER COLMAN

Small Motors

new, free catalog helps select exact motor needed

REVERSIBLE MOTORS
Compact, powerful, fast reversing . . . adaptable to a variety of control circuits. Available with gear trains, open or enclosed, in wide range of ratios. Rapid reversing and follow-up make these motors ideal for many electronic control circuits.

the complete line of Barber-Colman motors includes unidirectional, synchronous, and reversible motors—up to 1/20 hp. With and without reduction gearing—open or enclosed types. Expert engineering service available to help you get the exact motor for your application. Write for your free copy of new Catalog F-4271-6.

Barber-Colman Company

Dept. I, 1215 Rock Street, Rockford, Illinois

For more information circle **112** on inquiry card.

INSTRUMENTATION ENGINEER

There are a few select positions in General Electric's Small Aircraft Engine Department for well qualified engineers who are at home in the areas of instrumentation development. At the same time they must be able to take the initiative in developing new and higher standards.

A thorough knowledge of laboratory experimentation instruments is required and the ability to apply these in measuring aerodynamic flow, vibration, etc. One activity involves the development of general instrumentation; the other is the application of instruments to the testing of engines and engine components.

Work is in advanced areas where individual achievement is quickly recognized and rewarded. Starting salaries are high and are coupled with an outstanding benefits program. The location near Boston is well known as a cultural center.

For futher information write, giving details of education and experience in confidence to:

Mr. T. S. Woerz (Section 6-B)

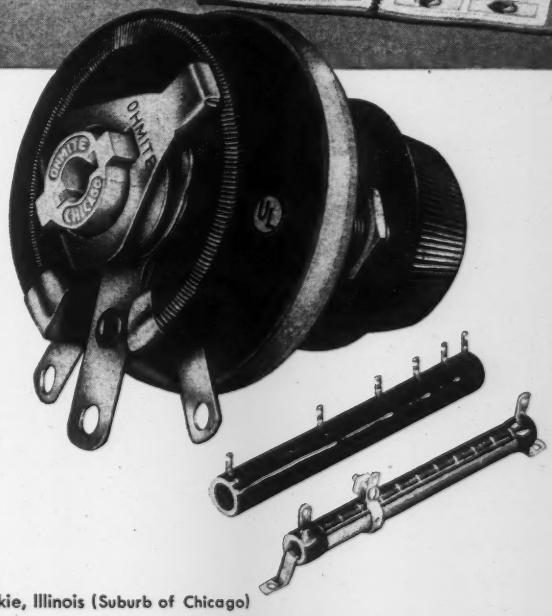
SMALL AIRCRAFT ENGINE DEPARTMENT

GENERAL ELECTRIC

1000 Western Avenue, West Lynn, Mass.

let OHMITE engineers "TEAM UP" with your engineers

IN SOLVING YOUR RESISTANCE PROBLEMS



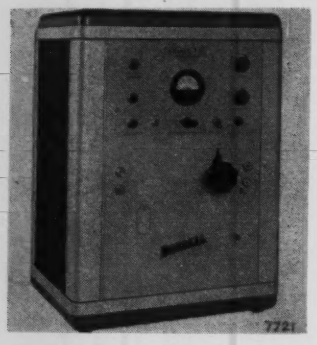
Save valuable engineering time . . . team up with Ohmite to solve your resistance problems. Ohmite engineers are resistance specialists . . . they can quickly analyze your requirements and recommend the correct rheostats and resistors to fit your application. Years of experience in building dependable resistance units . . . complete design, development and production facilities . . . plus a long record of helping others to economically solve their resistance problems . . . are your assurance that Ohmite can help you. We invite you to submit your resistance problems to us.

OHMITE MANUFACTURING COMPANY, 3615 Howard Street, Skokie, Illinois (Suburb of Chicago)

Be Right with - OHMITE®

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES • TANTALUM CAPACITORS

For more information circle 113 on inquiry card.

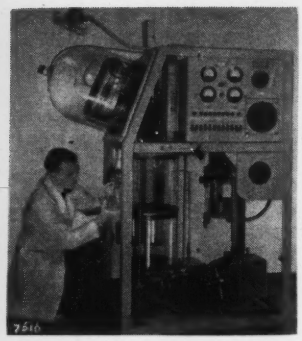


previous models; offers fast and accurate analysis of gases or liquids, even liquids boiling up to 300°C; can be bench-mounted or panel-mounted anywhere in lab or plant for process control.—*Burrell Corp.*, 2223 *Fifth Ave., Pittsburgh* 19, *Pa.*

For more information circle **331** on inquiry card.

CENTRIFUGAL MOLECULAR LABORATORY STILL

New "CMS-14" large low-priced lab centrifugal molecular still can simulate on a pilot-plant scale the molecular distillation obtained in costly commercial stills; permits distillation of heat-sensitive materials with molecular weights up to 1200 with less danger of thermal decomposition than



by any other accepted distillation method. Some substances with molecular weights as high as 4000 can be distilled safely.—*Consolidated Electrodynamics Corp., Rochester Div.*, 1775 *Mt. Read Blvd., Rochester* 3, *N. Y.*

For more information circle **332** on inquiry card.

X-RAY DIFFRACTION APPARATUS

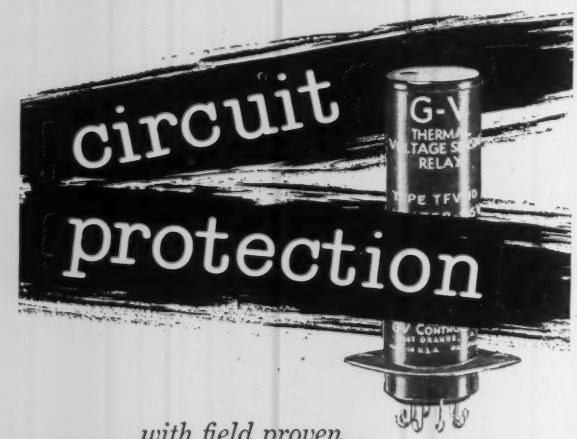
New "XRD-5" x-ray diffraction instrument permits rapid analysis, with high accuracy, thanks to use of a high-speed proportional counter and preamplifier. Proportional counter life is at least 1,000 times that of Geiger counters. Single-crystal orienting device now makes it possible to routinely identify unknown organic or inorganic single crystals, to analyze fibers and wires and study preferred

orientation bv reflection method.—*X-ray Dep't, General Electric*, 4855 *Electric Ave., Milwaukee* 1, *Wis.*

For more information circle **333** on inquiry card.

LABORATORY RELAY

New "Combined Electronic and Photocell Relay" is a versatile laboratory unit. As an electronic relay, it can be used for automatic control where control contacts cannot carry any appreciable current: it will operate whenever resistance between control posts is less than 2 megohms. A front-panel switch converts unit into a photoelectric relay. Lens and opening for photocell at side of case. Load contacts deliver up to 5 amp at 115 vac. Two output terminal plugs: nor-



with field proven

G-V THERMAL SENSING RELAYS

G-V Sensing Relays operate contacts when current or voltage to their heaters exceeds or drops below the operating point. They can be selected with a response rate paralleling the action of the equipment. These relays operate quickly on heavy changes but tolerate slight changes until they become dangerous.

Meets military requirements

Write for Engineering Assistance and complete technical Data. Ask for Publication 70.

G-V CONTROLS INC.

38 Hollywood Plaza, East Orange, N. J.

For more information circle **114** on inquiry card.

INSTRUMENTATION ENGINEER

Position On Advanced Level For Man With Sound Engineering Judgement

Opportunity to design and engineer complete systems, starting from process flow sheet, selecting instruments, maintaining control record, following entire instrumentation drafting job, **checking installation,** and, at times, assisting in plant start-up and operation. Design criteria includes cost, maintenance, employee safety, and insurance specifications. Occasionally make instrumentation cost estimates in conjunction with bids for new jobs.

Requirements: 10 years experience in instrumentation, application, specification, and installation, covering pneumatic and electronic instruments in chemical and/or refinery industries. Includes layout of graphic panels.

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MIDTOWN NEW YORK LOCATION

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Mr. Robert L. Ford, Personnel Mgr.

Chemical Construction Corp.
525 West 43rd Street New York, N. Y.

Ever had an entire development project stalled while mountains of raw test data were being processed? Then it's time to take a careful look at CEC's MilliSADIC Systems, today's most widely used high-speed, analog-to-digital data-processing equipment. Month in, month out, MilliSADIC Systems—designed, manufactured, and installed by CEC's Systems Division—are busy breaking data bottlenecks. They are saving both dollars and engineering man-hours at engine-test facilities, missile telemetering stations, and data-processing centers everywhere.

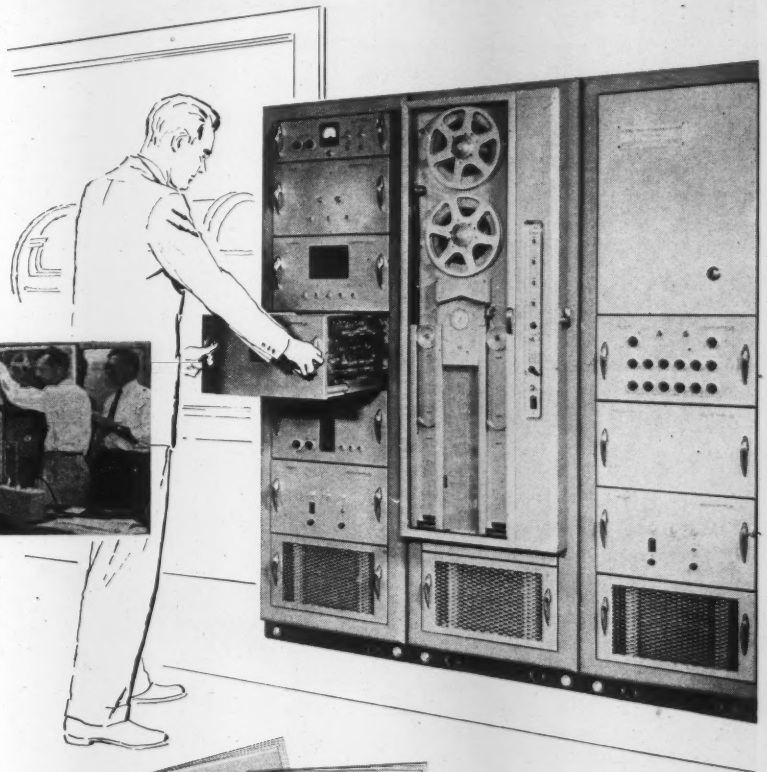
Although custom-engineered for each data-processing application, MilliSADIC Systems achieve true economy—and unusual dependability—through the use of standardized component modules. They may be expanded or adapted to new test demands with a minimum of equipment replacement. Both input and output characteristics are compatible with standard data-acquisition, recording, and processing instruments, and the Systems Division can supply integrated MilliSADIC Systems, complete from transducer to electronic digital computer.

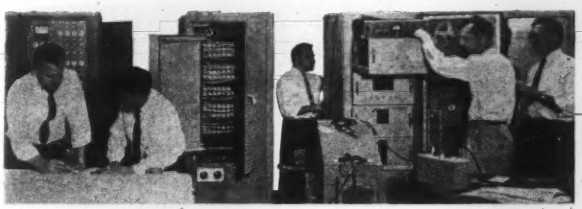
from **CEC**'*s Systems Division*

DATA PROCESSING

MilliSADIC *Systems...*

high-speed, economical, flexible





INPUTS

MilliSADIC Systems accept inputs in the form of (1) analog voltages, (2) pulse durations, and (3) pulse trains. With the use of suitable analog-signal-conditioning equipment, a wide range of analog-voltage input levels may be handled. MilliSADIC Systems are particularly valuable for reduction of data recorded on magnetic tape.

OUTPUTS

MilliSADIC Systems are equally flexible in their mode of output presentation. In general, within the capabilities of the analog-to-digital converter (1500 samples per second) the nature of the readout device determines sampling speed. Output may be in the form of punched paper tape, magnetic tape, punched cards, or may be fed directly to an electronic digital computer, such as the ElectroData Corporation's "Datatron."

For further information write for Systems Engineering Bulletin CEC 1304-X32, and MilliSADIC Bulletin CEC 3003-X2.

Systems Division

Chemical Analysis

Process Monitoring and Control

Dynamic and Static Testing

Consolidated Electrodynamics

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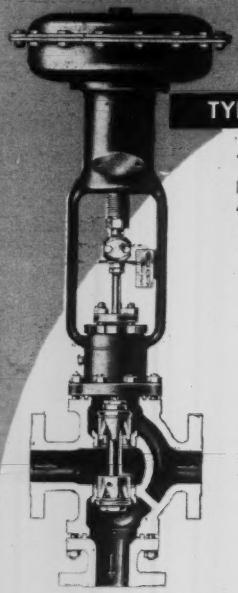
Electronic Instruments for Measurement and Control

For more information circle **115** on inquiry card.

FISHER®

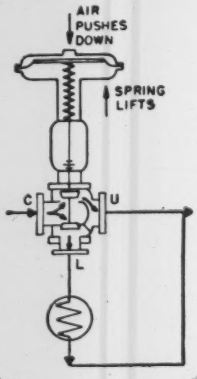
THREE-WAY DMVS

FOR BY-PASS, MIXING or BLENDING SERVICE



TYPE 657-YY

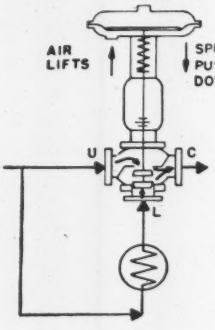
Three-way control valve for by-pass or proportioning service. Available all castable alloys sizes ½ thru 12".

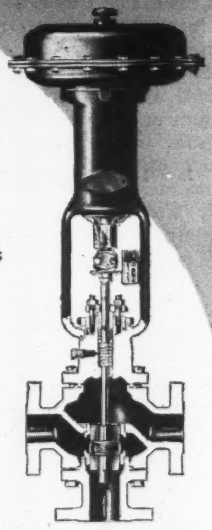


By-pass flow is from "C" to "U" with no air on diaphragm. Flow through heat exchanger from "C" to "L" with air on diaphragm.

TYPE 667-Y

Three-way control valve single disc type for by-pass or mixing applications. Available all castable alloys sizes ½ thru 12".

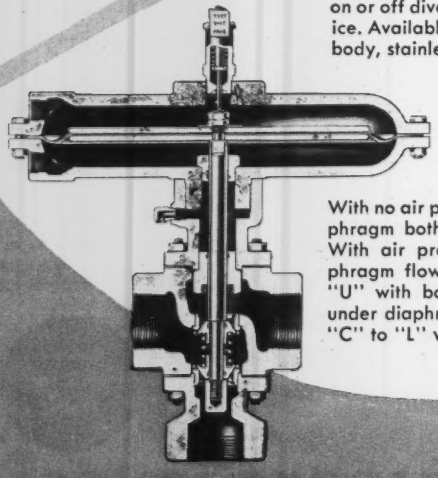


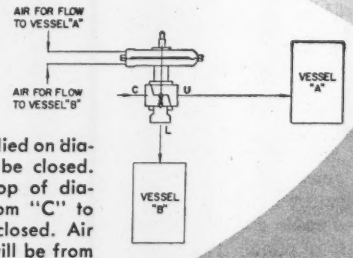


Normal flow is from "U" to "C" with air off diaphragm. With air under diaphragm flow is through exchanger from "L" to "C".

TYPE 1620

Three-way, three-position valve for on or off diversion and shut-off service. Available with 2" screwed steel body, stainless steel trim.





With no air pressure applied on diaphragm both ports will be closed. With air pressure on top of diaphragm flow will be from "C" to "U" with bottom port closed. Air under diaphragm flow will be from "C" to "L" with upper port closed.

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MARSHALLTOWN, IOWA • WOODSTOCK, ONTARIO

LEADS THE INDUSTRY IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

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For more information circle **116** on inquiry card.

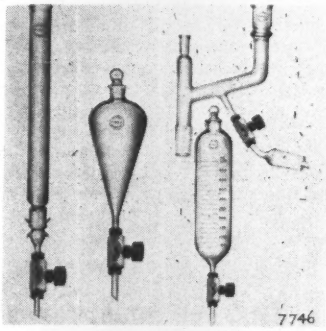
NEW INSTRUMENTS

mally-open and normally-closed. Neon pilot lights are attached to both output plugs. Cold-cathode tube requires no stand-by current and no warm-up time.—*Wabash Instrument & Specialties Co., Inc., Box* 194, *Wabash, Ind.*

For more information circle **334** on inquiry card.

GLASSWARE ACCESSORIES

New "Pyrex" brand glassware accessories, for use with "Manostat" glass and Teflon needle valves, offer



extremely sensitive reproducible flow control; include separatory funnels of all types, chromatographic columns, still heads, etc.—*Emil Greiner Co.*, 20-26 *N. Moore St., New York* 13, *N. Y.*

For more information circle **335** on inquiry card.

DEMINERALIZER

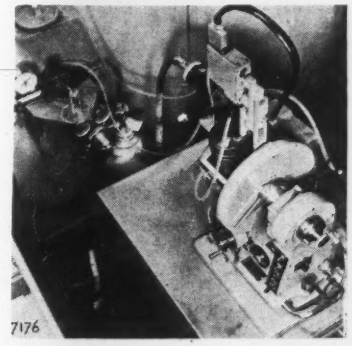
New. low-cost portable "Crystalab Deemajet Model DJ-128" ion-exchange water de-ionizer is pressure operated;

connects to any faucet and yields instantly de-ionized water of high quality at a flow rate as great as 2 gpm. Grain removal capacity about 1750 grains as NaCl.—*Crystal Research Labs., Inc.*, 29 *Allyn St., Hartford* 4, *Conn.*

For more information circle **336** on inquiry card.

FLOW PROPORTIONAL COUNTER

New "Norelco" flow proportional counter effectively detects and measures all elements down to and includ-



ing magnesium (No. 12), has high rate (over 60,000 counts per second for soft radiation) and "excellent reproduction qualities."—*North American Philips Co., Inc.*, 750 *S. Fulton Ave., Mt. Vernon, N. Y.*

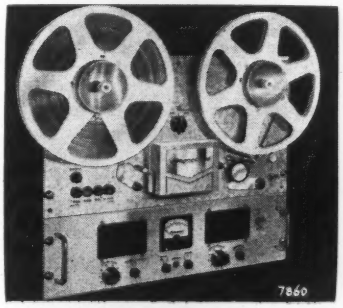
For more information circle **337** on inquiry card.

MISCELLANEOUS

TAPE RECORDER

New "P-60-ACX Editor" features versatility, ease of operation and accuracy for professional broadcasting and recording, also scientific and industrial applications—*Magnecord, Inc.*, 1101 *S. Kilbourn Ave., Chicago* 24, *Ill.*

For more information circle **338** on inquiry card.

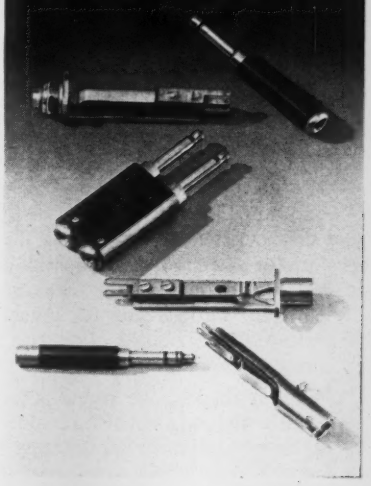


TELEPRINTER TERMINAL

New "Type 6-C Interlink Converter" is a multi-purpose unit designed to meet all terminal requirements in point-to-point teleprinter service; can

SWITCHBOARD-PROVED

Plugs and Jacks



The veteran of telephone equipment suppliers

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offers you the plugs and jacks which survive the torture test of PBX switchboard work!

No matter what programming or patch panel project you have, we doubt if it will subject plugs and jacks to a tougher test than daily use by a telephone switchboard operator.

We've been making these products for this purpose for over half a century. Their ruggedness and dependability are attested by service records in telephone companies from coast to coast—and in installations of our armed forces all over the world.

A CATALOG of Plugs and Jacks has just come off the press and will be mailed to you on request. Or write to the address below for a specific need you may have.

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TELEPHONE INDUSTRIAL SALES

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For more information circle **117** on inquiry card.

The Curtiss-Wright "SNAPPER"

NEW CONCEPT... ADVANCED DESIGN IN THERMAL TIME DELAY RELAYS

Designed for high performance and long life, the Curtiss-Wright "SNAPPER" Thermal Time Delay Relay is proving itself in countless applications involving time delay in electrical circuits. Such applications include circuits to provide definite on-off time intervals to delay the application of high voltage until after warm-up period and for over and under voltage protection with simultaneous fault indication.

These relays have single-pole double-throw contact action, high ambient temperature range, freedom from chatter and arcing, and are small in size. The "SNAPPER" thermal time delay relays are factory pre-set from 3

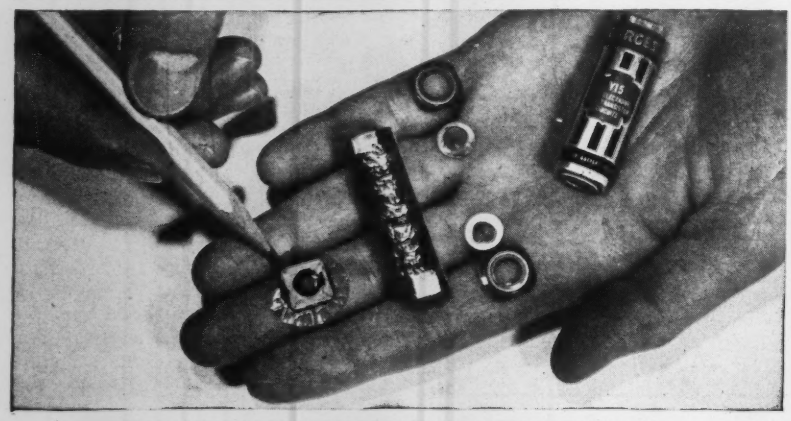
U. S. Pat. No. 2658975

to 120 seconds. They are available in metal envelope, miniature (7 and 9 pin) or octal (8 pin) and in a glass envelope in 9 pin only.

Curtiss-Wright manufactures the High-Low "SNAPPER" Differential Thermostat with high precision characteristics. Write to Thermal Devices for complete information.

ELECTRONICS DIVISION
CURTISS-WRIGHT
CORPORATION · CARLSTADT, N. J.

For more information circle **118** on inquiry card.



REVOLUTIONARY BURGESS "WAFER-CELL" offers

SMALL, COMPACT POWER PACKAGES

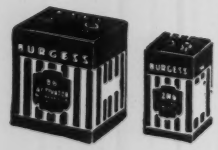
A major step toward the application of automation to the manufacture of dry batteries has been achieved with the development of the new BURGESS "WAFER-CELL" making possible a 30 PER CENT INCREASE IN BATTERY LIFE.

The new cell consists of a sandwich of artificial manganese dioxide mix between tiny discs of flat zinc and carbon electrodes wrapped in pliofilm envelopes and heat sealed. A dab of SILVER WAX on the positive and negative sides of the cells permits stacking them in a column eliminating welded or soldered connections. Rigid inter-cell connections are maintained since the silver wax yields and molds itself to any necessary configuration between the cells to hold PERFECT ELECTRICAL CONTACT.

Small batteries for hearing aids, pocket radios, B-C photo guns and transistorized instruments are made by wrapping the cell stack in MYLAR FILM and packaging it in a leakproof tube of drawn aluminum.

Your local Burgess distributor carries complete stocks of fresh BURGESS BATTERIES including new "Wafer-Cell" types.

BATTERY DESIGN SERVICE AVAILABLE



The same engineering "know-how" that made possible the new "Wafer-Cells" is available TO YOU. Long before you run into a battery design problem, call on Burgess for expert battery design assistance.

BURGESS BATTERY COMPANY

FREEPORT, ILLINOIS

For more information circle **119** on inquiry card.

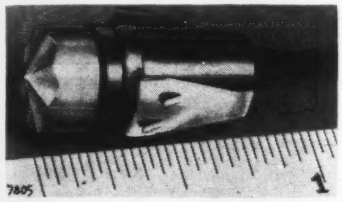
NEW INSTRUMENTS

also handle many remote operations; operates on a single pair of lines, reduces effect of cross-talk and errors of human failure, eliminates normal switching and can operate several teletype printers simultaneously.—*H. O. Boehme, Inc.*, 915 *Broadway, New York* 10, *N. Y.*

For more information circle **339** on inquiry card.

TINY INDICATOR LIGHT

New "Pan-i-Lite" features bulb 1/6 the size of "miniature" bayonet bulbs. Bulb filament is sealed high up in



its own translucent lens to keep light intensity in front of panel and obviate need of focusing effects, bulky magnifying lenses, or refracting devices. Its brilliance is said to be "as great as that of the large bull's eye types." It is visible from any angle. Bulb lens assembly is instantly replaceable from front of panel. Voltages: 6, 12, 28 incandescent and 110/220 neon.—*Alden Products Co., Dept. Pan-57, 117 N. Main St., Brockton, Mass.*

For more information circle **340** on inquiry card.

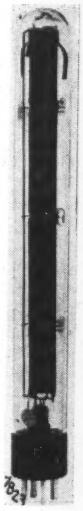
RAINFALL INDICATOR

New "Model 10B Raindicator" records total rainfall in increments of hundredths of an inch. It is unique in

that it operates on electro-calorimetric principle, i.e., a fixed quantity of water at a fixed temperature and atmospheric pressure will require a known amount of electric energy to convert it into steam. Features: remote indication (on instrument illustrated), simplicity of operation, ease of installation, absolute method of measurement and provision for instantaneous rate recording.—*Airtronic Research, Inc.*, 5522 *Dorsey Lane, Washington* 16, *D. C.*

For more information circle **341** on inquiry card.

PHOTOTUBE

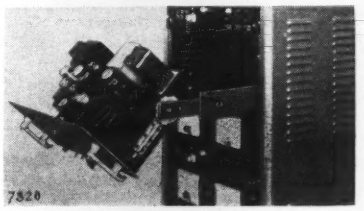


New "XR-673A" features a 7½" cathode which is said to open up "a multitude of new application" because it obviates need of a bank of smaller phototubes, cuts down on circuitry and assures stability of output over its entire length. Peak sensitivity is in blue—particularly useful with light sources such as mercury-vapor lamps. Nominal sensitivity 120 uamp/lumen read at 0.1 lumen on a spot ½" diameter with a tungsten filament lamp operated at 2870°K at anode voltage of 90 vdc, 1-megohm load resistor. Maximum anode voltage 90 vdc. This phototube can also be supplied in vacuum.—*Continental Electric Co., Geneva, Ill.*

For more information circle **342** on inquiry card.

CABINET SLIDE

New Model of "Chassis-Trak" features 300% increase in bearing surfaces. Mounted components can be

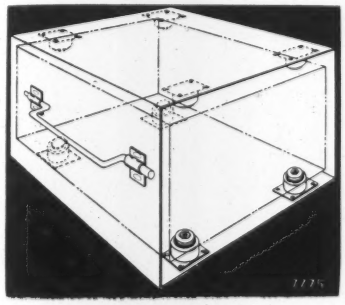


pulled out, locking in automatic "out" position. Pushbutton removal of entire chassis speeds emergency replacement of units. New slide attaches to any standard 17" chassis and fits 19" panel racks without alteration to chassis or racks. (Others fit cabinets from 10" to 24" deep). All parts are standardized and interchangeable; installation takes 15 min.—*Chassis-Trak Corp., 6252 Iona Road, Indianapolis, Indiana.*

For more information circle **343** on inquiry card.

ALL-METAL PACKAGING

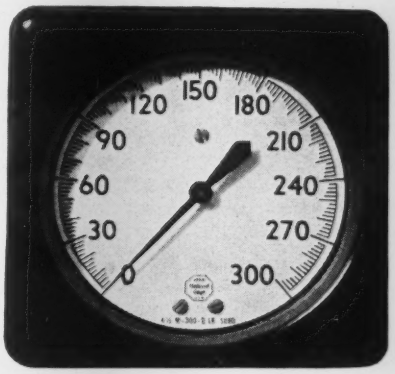
New metal mounts for transit cases protect shipped instruments and delicate equipment against shock and vibration; fit any widely-used reusable



ACCO products

Helicoid Gages

Long-life gages to meet every pressure indicating requirement



Acaloy square case for flush mounting

Acaloy flanged case

For pressure, vacuum or compound service

Ranges from 15 to 20,000 p.s.i.

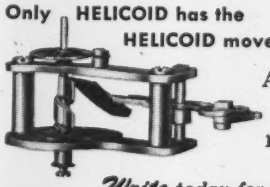
Tubes of bronze, alloy steel, stainless steel and K Monel for all types of gas or liquid.

Cases are flanged, flangless, flush mounted, square or circular and with white or black dials.

Chemical gages with diaphragms to seal off objectional substances from indicating gage.

Chemical gage with black dial

Only HELICOID has the HELICOID movement



All HELICOID Gages provide the sustained accuracy that only the famous HELICOID—no gears—movement provides.

Write today for the **HELICOID G-2 CATALOG**

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TRADE MARK

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Better Value

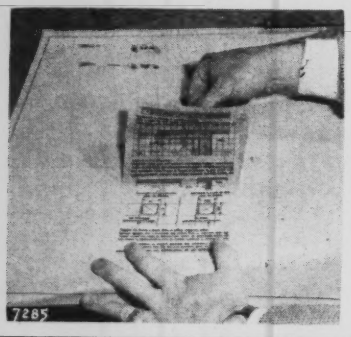
For more information circle **120** on inquiry card.

container; resist extreme temperatures, water, dirt, oil, insects and fungus during long storage periods. Equipment stays inside its container without slippage or smashing-in of container walls. Principle of opposed cushioning is used for strengthened support.—*Robinson Aviation, Inc., Teterboro, N. J.*

For more information circle **344** on inquiry card.

CIRCUIT DESIGN AID

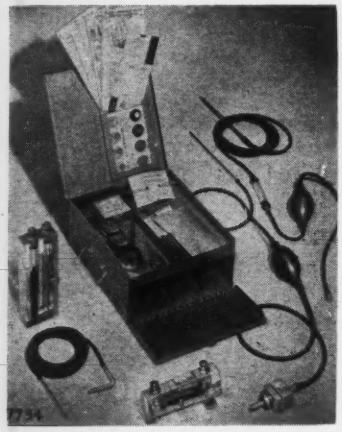
New "Stanpat" custom-printed matte-surface adhesive acetate obviates need of circuit details being tediously hand-drawn and re-drawn in ink on Bristol board; eliminates boresome repetitive and expensive copying; minimizes drafting errors. ★ New "709T" adhesive won't come off, dry out or wrinkle; is unaected by any reproduction process.—*Stanpat, 150-42 12th Road, Whitestone 57, N. Y.*



For more information circle **345** on inquiry card.

COMBUSTION TEST KIT

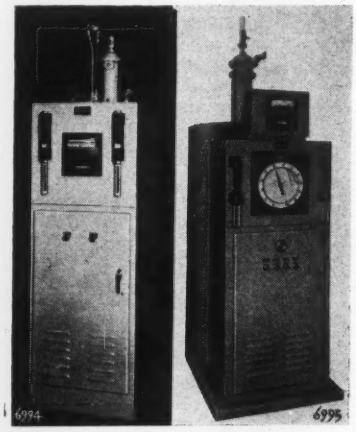
New "No. 1100 Combustion Test Kit" checks CO_2 content, draft, stack temperature and smoke in all gas, oil- or coal-fired installations. Once set up, gages can be read in 30 seconds. Any apprentice can use it correctly.—*F. W. Dwyer Mfg. Co. Dept. IUP, P.O. Box 373, Michigan City, Ind.*



For more information circle **346** on inquiry card.

ENDOTHERMIC GENERATORS

New "G-150-E" lab-size electrically heated generator has rated output of 150 cfh of prepared atmosphere gas; but output can be increased by about 50% when required. ★Larger unit combines a gas-fired endothermic generator with "Dewtronik" recorder-controller for automatic dew-point control of base generator gas, giving continuous automatic control of prepared base gas analysis.—*Ipsen Industries, Inc., 715 South Main Street, Rockford, Illinois.*



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For more information circle **121** on inquiry card.

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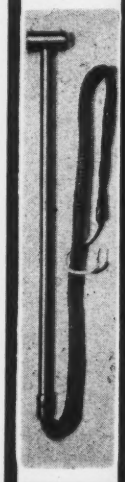

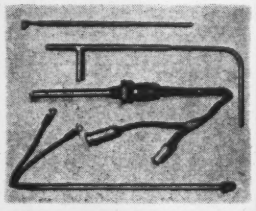

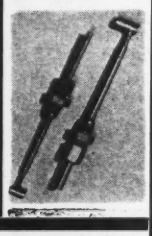

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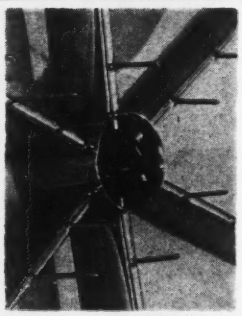

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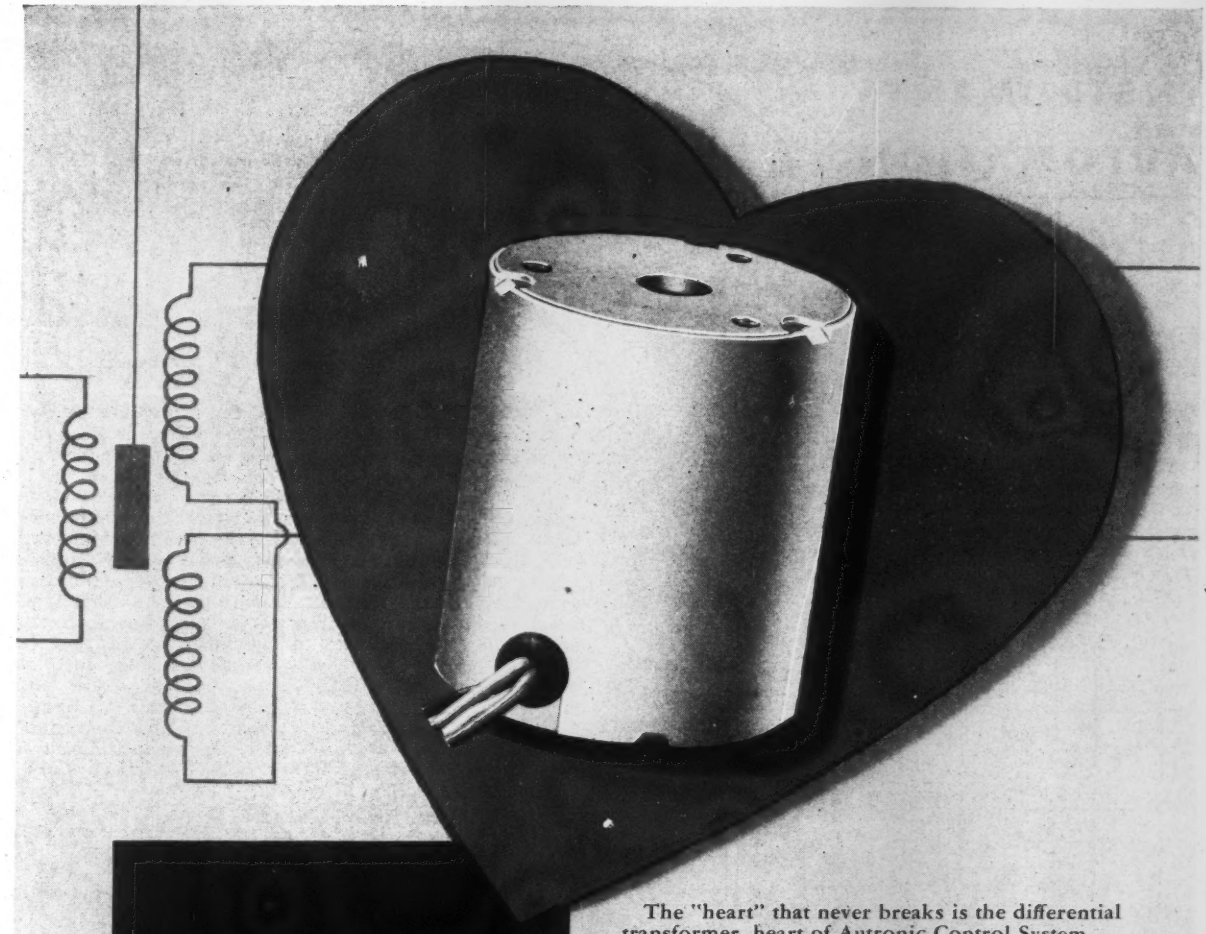

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Whether for measuring pressure, flow, level, or any displacement, you can't match the rugged simplicity of a differential transformer. There are no orifices . . . no vacuum tubes or transistors . . . no moving parts to cause shut-downs or maintenance problems. In addition to its reliability under adverse environments, the differential transformer has many distinct advantages over all other sensing devices. Among these are infinite resolution . . . performance that's linear to better than 0.1% of span . . . high signal output level . . . low impedance . . . ability to add, subtract or average signals.

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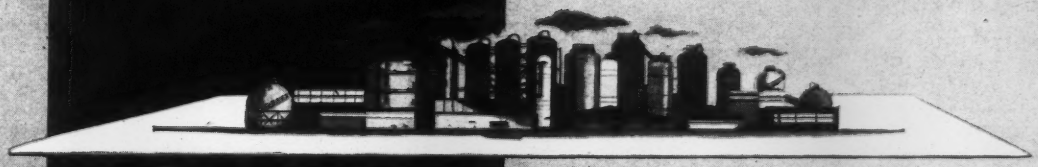

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Sept. 17-21

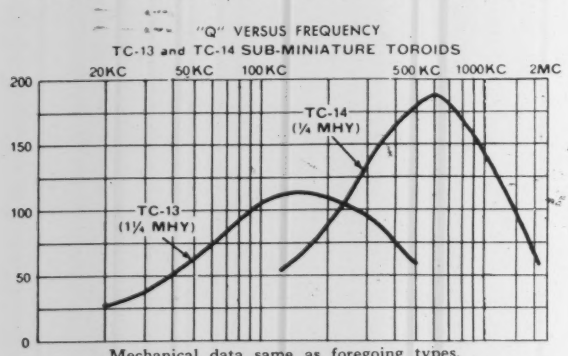
For more information circle **123** on inquiry card.

INSTRUMENTS and AUTOMATION Briefs

For this literature circle number on inquiry card.

Toroids

The merits of the toroidal type winding coupled with the numerous advantages of the molybdenum permalloy dust core represent the criteria in coil characteristics for audio applications. These toroids provide higher Q, greater stability of inductance vs. temperature and level in a



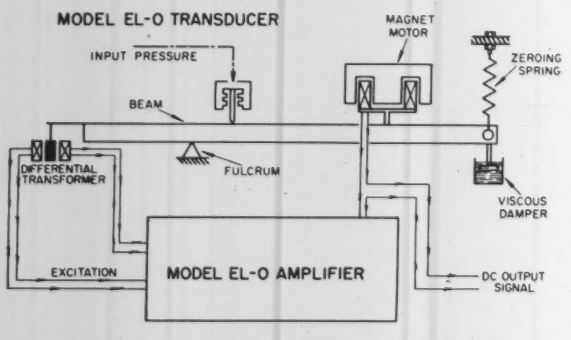
Mechanical data same as foregoing types.

smaller space than any other available structure . . . Coils are supplied to an inductance accuracy of 1% . . . Most useful frequency range of the subminiature Type TC-13 is between 40 and 400 kc. Available up to 100 MHYS with optimum characteristics below 10 MHYS.—(*From new* 16-*page Cat. No.* 103, *Burnell & Co., Inc.*, 45 *Warburton Ave., Yonkers* 2, *N. Y.*)

For this literature circle **401** on inquiry card.

Aerodynamic Research

The measurement (Models "A" and "AD" Pressure Transducers) is made in a bellows system and the resultant force is balanced by a coil operating in the field of a permanent magnet. The output of a differential transformer operated by the bellows system is rectified and amplified in the amplifier for the feedback system . . . . In



the Model EL-O Pressure Transducer a pressure bellows moves one end of a feedback stabilized beam, the other end of which drives a differential transformer to generate an output voltage proportional to beam movement . . .

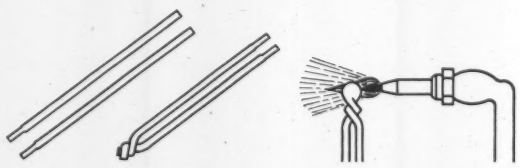
The model P Amplifier is used for such applications as stress analysis, temperature and temperature difference measurements, preamplification, and in computer and transducer applications. The instrument accepts signals from strain gage transducers, thermocouples, radiation pyrometers, thermistors or resistance thermometers. Temperature difference measurements as low as 15°F can be made in combination with thermocouples . . . . Designed for introducing electronically sensed variables such as pressure, temperature, differential pressure, flow and others into basically pneumatic control systems, the Hagan Electro-Pneumatic Controller makes available the highest frequency response performance in the pneumatic control field. (*From new* 20-*page Bulletin MSP*-133, *Hagan Corp., Pittsburgh* 30, *Pa.*)

For this literature circle **402** on inquiry card.

How to Make a Thermocouple

Cut both wires to the length of the finished thermocouple. Remove the oxide for a distance of about one inch from one end of each wire with a grinding wheel.

Fasten the unground ends of the wires in a vise, with both wires extending the same distance. Twist these two ends together so that there are at least three turns of the wire, being sure to protect against marks from vise on wires, which may shorten life of thermocouple.



When welding use an acetylene torch, and select a torch tip in proportion to the size of wire to be welded.

Hold the twisted junction of the wires in the flame—at the tip of the white cone—until both wires are a bright red, then dip in a fluxing mixture consisting of 6 parts of fluorspar to 1 of borax. (If fluorspar is not available, borax alone may be used). Place the flux convered twisted ends immediately in the flame.

Since one wire melts at a lower temperature than the other, manipulate the weld in the flame until both wires reach their melting points at about the same time. This can be done by keeping the wire that melts first in the cooler part of the flame until the other wire is about to melt. (*From new* 44-*page Data Book and Catalog, which includes Thermocouple Tables and Symbols, Temperature Conversion Chart, etc., Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.*)

For this literature circle **403** on inquiry card.

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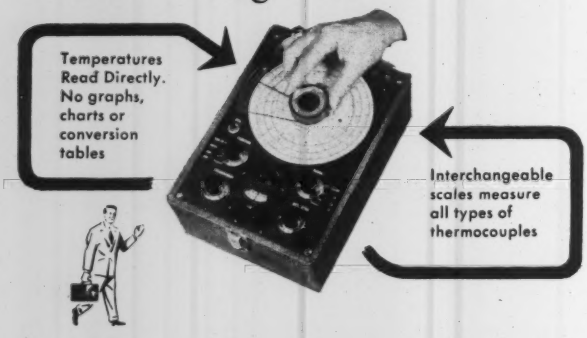
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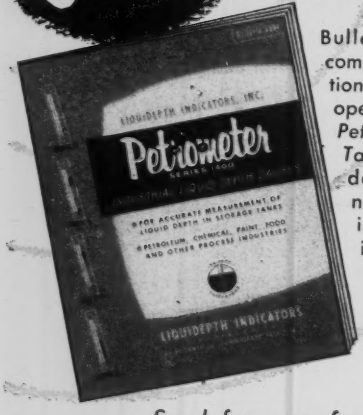
For more information circle **125** on inquiry card.

How to Choose THE RIGHT REMOTE READING TANK GAUGE



Bulletin 6004 presents comprehensive information on the selection and operation of the *New Petrometer Series 1400 Tank Gauges*. It also describes the many new design features incorporated in the indicators to provide quick, easy installation, trouble-free automatic operation and accurate indication.

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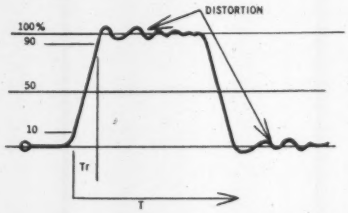
For more information circle **126** on inquiry card.

BRIEFS—CONTINUED

Delay Lines

In a typical test circuit, a delay line displays a pulse similar to that shown in the illustration. Definitions of common delay line terms in general usage are as follows:



Z_1 = Input Matching Impedance: that network which matches generator output to delay line impedance.

Z_o = Characteristic Impedance of Delay Line: that impedance which when terminating the output, will minimize the amplitude of reflection as viewed at the input.

T_r = Rise Time: the time (usually in microseconds) required for the pulse amplitude to rise from the 10% to 90% points on the pulse leading edge. True rise time of a component or a network, is expressed by $T_r = T_0^2 - T_1^2$ where T_r = true rise time, T_1 = input rise time, T_o = ouput rise time. (*From new 8-page Pamphlet "Application-Tailored Delay Lines," Brubaker Electronics, Inc., 3652 Eastham Drive, Culver City, Calif.*)

For this literature circle **404** on iniquiry card.

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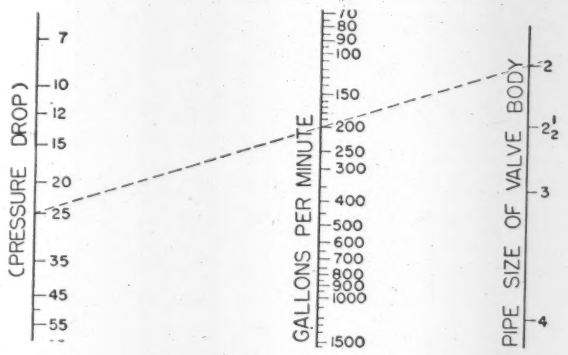
For more information circle **127** on inquiry card.

Solenoid Valves

Power consumption of Solenoid Valves can be determined from the rating in ASCO Bulletins. For valves on A.C. service, the watt rating, the volt-amp "inrush" and the volt-amp "holding" are given. The volt-amp "inrush" is the high momentary surge of current which occurs at the moment an A.C. solenoid is energized. The volt-amp "holding" is the continuous rating after the initial "inrush."



The current rating for the "inrush" and "holding" can be determined by dividing the voltage into the volt-amp rating.

Valves supplied for D.C. service have no "inrush" current, as in the case of A.C. service. The amp rating can be determined by dividing the voltage into the D.C. watt rating. (*From new 36-page Condensed Valve Catalog No. 201, which includes nomographs for air, gas, and water flow for standard full area valves, Automatic Switch Co., Orange, N. J.*)

For this literature circle **405** on inquiry card.

FREE SELECTION CHART for AGASTAT® time delay relays

Now you can select exactly the right Agastat time delay relay for your particular timing need—in a hurry. This free selection chart lists data on every popular model in the Agastat line—the most complete line of pneumatic time delay relays in the industry. They're adjustable for timing from 0.1 second to 10 or more minutes, unaffected by voltage variation, dustproof, light, and mountable in any position. And there's an Agastat model to precisely fit your requirements, including two-step, electrical interlock and double head units. A glance at the free selection chart tells you which model to order.

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Elastic Stop Nut Corporation of America

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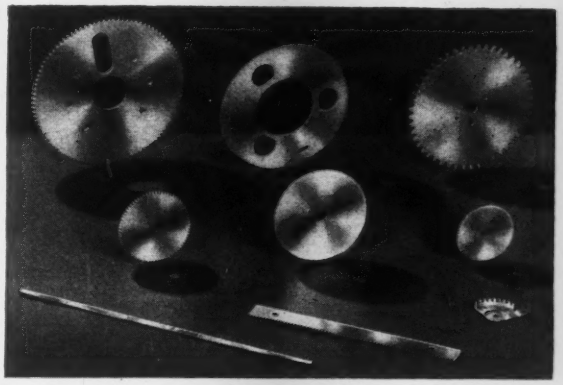

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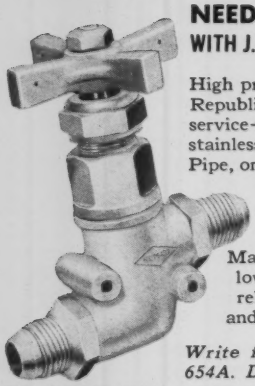

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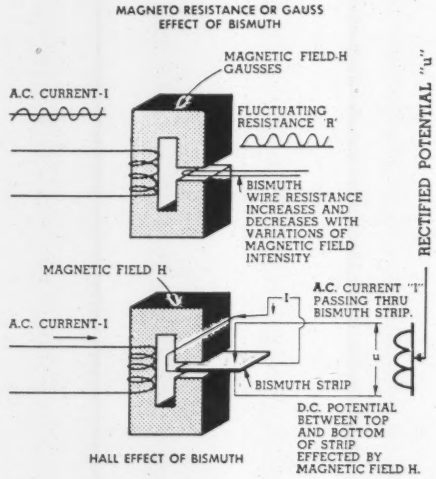
BRIEFS—CONTINUED

Ductile Bismuth Wire

Probably the most important characteristic of bismuth wire is its large increase in resistance when placed in a magnetic field. Between the values of 2,000 and 35,000


MAGNETO RESISTANCE OR GAUSS EFFECT OF BISMUTH
MAGNETIC FIELD-H GAUSSES
A.C. CURRENT-I
FLUCTUATING RESISTANCE 'R'
BISMUTH WIRE RESISTANCE INCREASES AND DECREASES WITH VARIATIONS OF MAGNETIC FIELD INTENSITY
RECTIFIED POTENTIAL "u"
MAGNETIC FIELD H
A.C. CURRENT "I" PASSING THRU BISMUTH STRIP.
A.C. CURRENT-I
BISMUTH STRIP
D.C. POTENTIAL BETWEEN TOP AND BOTTOM OF STRIP EFFECTED BY MAGNETIC FIELD H.
HALL EFFECT OF BISMUTH

gauss, its proportionate response is approximately 214% at 18°C. (Taken from Smithsonian tables). From 300 to 2,000, the proportionate response is less tho sensitive enough for electrical instrumentation. (*From new 28-page Ductile Bismuth Wire Bulletin, second edition, Fitzpatrick Electric Supply Co., 444 Irwin St., Muskegon, Mich.*)

For this literature circle **406** on inquiry card.

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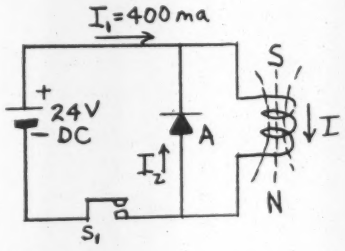
Selenium Contact Protectors

What causes arcing in inductive circuits?

Immediately upon opening of S_1, when the flow of current is suddenly stopped, the voltage which appears across the coil could theoretically go to infinity. Due to insulation resistance and other factors actually the voltage may rise to 300 to 1,000 volts in an average 24 volt coil. Air is not a perfect insulator, therefore, at the instant S_1 is broken and the coil voltage appears across the contacts an arc occurs . . . Federal's contact protector is a form of



selenium rectifier thus: when a contact protector cell "A" is hooked up across the coil terminals in direction shown in the figure there will be none of the 400 ma coil current flowing in "A" while the contacts S_1 are held closed . . . Federal's contact protectors are NOT ordinary selenium rectifiers. This blocking cell "A" has been specially processed to exhibit favorable characteristics such as very low leakage current, low forward resistance and long life . . . (*From new 7-sheet bulletin "The A-B-C's of Contact Protection," Federal Telephone and Radio Corp., 100 Kingsland Rd., Clifton, N. J.*)

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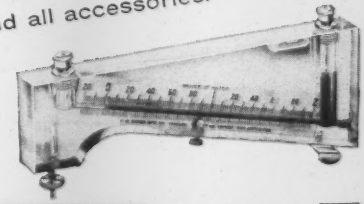

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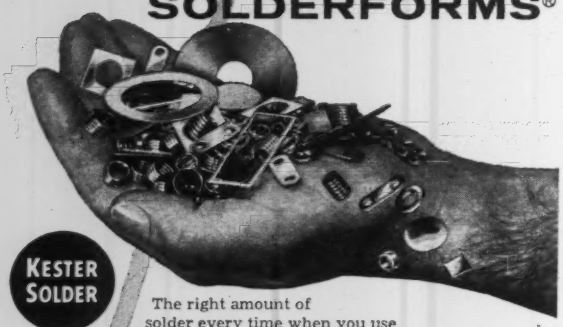

KESTER SOLDER

The right amount of solder every time when you use Kester Solderforms in your assembly operation. Produce better looking and more efficient products as well as greatly increase speed of manufacturing.

WHERE TO USE KESTER SOLDERFORMS

Capacitors • Switches • Resistors • Transformers
Relays • TV and Radio Tuners • Gauges • Small Metal Assemblies and Controls . . . many, many others.

WRITE TODAY for free samples and complete information

KESTER SOLDER COMPANY 4270 Wrightwood Avenue, Chicago 39, Illinois
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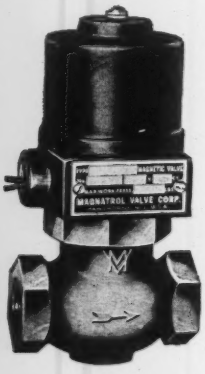
For more information circle **137** on inquiry card.

Eliminate
Costly Flow Failures



Magnatrol
SOLENOID VALVES

Quick Operating *Non Sticking* *Tight Seating*

These three design advantages are your assurance against costly flow failures. Attain dependable, accurate, automatic or remote control of liquids or gases with **Magnatrol Valves.** Installed quickly and easily in connection with . . . flow-meters, thermostats, float and time switches. **Every Magnatrol Valve** is delivered to you—factory **tested**—guaranteed free from defects in material and workmanship.

Available in normally closed or normally open models. Pressure ranges from zero up to 300 PSI. Voltages to 575.

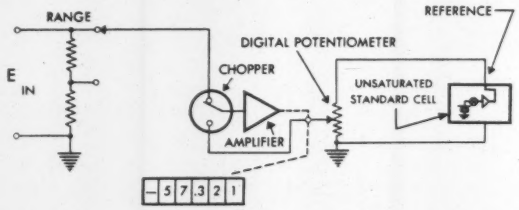
Catalog containing complete specifications mailed upon request.

Magnatrol VALVE Corp.
HAWTHORNE 14
NEW JERSEY

For more information circle **138** on inquiry card.

DC Digital Voltmeters

Dc measurement is accomplished by comparing the unknown voltage against an extremely stable reference which is incrementally varied by automatically switching



decades of precision resistors arranged in a Wolff bridge circuit. Visual read-out is derived through contact closures operating incandescent lights on the edges of engraved lucite plates arranged in depth. Recording is accomplished by providing parallel contact closures for direct operation in decimal system machines. Calibration is checked by comparing the reference against an internal standard cell, either automatically or manually. (*From new 6-page Bulletin "DC Digital Voltmeters," Electro Instruments, Inc., 3794 Rosecrans St., San Diego, Calif.*)

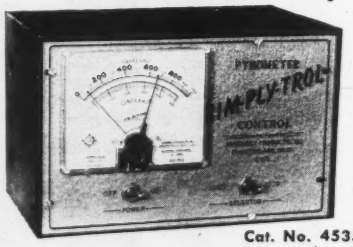
For this literature circle **408** on inquiry card.

Ri-Fi Meter

The NM-40A is primarily designed for use in interference surveys to determine the source and magnitude of radiated and conducted interference at any frequency within its operating range. It can perform the following additional functions:

1. As an ultra-sensitive harmonic wave analyzer, for the measurement of individual sine wave components of

SIMPLYTROL AUTOMATIC PYROMETERS
For Control of Temperature

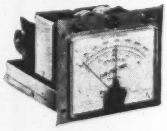


10 standard ranges from —200° to +3000° F.
Accuracy 2% (limit of calibration error).
Sensitivity 4 ohms per millivolt.

Cat. No. 4535, size 10" x 6" x 7". Range 0/1000° F,0/500°C. **$135.00**

Thermocouple-type automatic pyrometer for controlling temperature in furnaces or ovens and manufacturing processes. Leads between Simplytrol and its thermocouple sensing element may be up to 100 feet or more depending on temperature range and lead wire resistance. Load relay, 5 amperes S.P.D.T. Optional heavy duty relays to 40 A.

Either AUTOMATIC control or LIMIT shutoff. An automatic Simplytrol turns heat on and off to hold required temperature. Proportioning effect can be increased or decreased by changing cam on the sensing cycle. With shorter cycles, control more nearly approaches straight line. A limit Simplytrol locks up when the trip point is reached and remains locked until reset. Use limit Simplytrols for monitoring and safety shutoff or alarm.

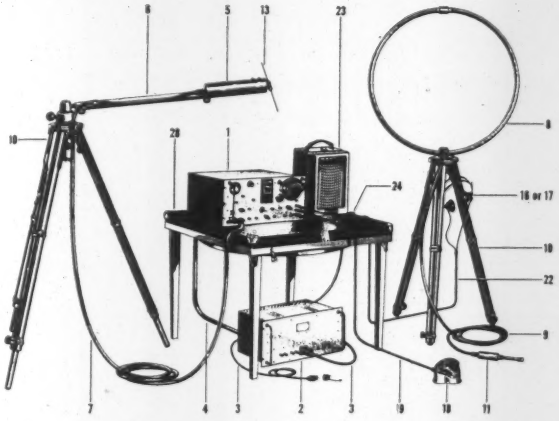


Cat. No. 4532-MFP, size 5"x5½"x8" deep. Range 0/1500°F, 0/800°C. **$127.00**

Cabinet model for wall mounting or portable shown at top. To the right is an MFP Simplytrol for flush mounting in a cabinet or control panel. Several other mountings are shown in Catalog 4-A. Send for your copy. **Assembly Products, Inc., Chesterland 10, Ohio.** Phone (Cleveland, O.) HAmilton 3-4436. (West Coast: Desert Hot Springs 10, Cal. Phone 4-3133 or 4-2453).

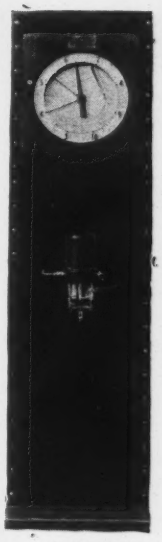
Booth 1614, Instrument-Automation Show, Sept. 17-21, New York Coliseum

For more information circle **139** on inquiry card.



a complex waveform . . .2. As an ultra-sensitive frequency-selective (tunable) voltmeter within the audio spectrum, for measurement of RMS, average, quasi-peak or true peak values of audio-frequency signals . . .3. Separate analysis may be made of the electric and magnetic components of an electromagnetic field, whether existing independently or related to each other . . .4. May be used for acoustic or vibration analysis in conjunction with transducers . . .5. When used in connection with a receiver or Radio Interference and Field Intensity Meter of any chosen frequency range, the NM-40A will measure and analyze the hum, noise, and modulation present on CW signal. (*From new 4-page Folder "Radio Interference and Field Intensity Measuring Equipment," Stoddart Aircraft Radio Co., Inc., 6644 Santa Monica Blvd., Hollywood 38, Calif.*)

For this literature circle **409** on inquiry card.



Single-Point pH Recorder (Strip Chart Assemblies also available)

CAMBRIDGE pH INDICATORS and RECORDERS

Labor saving—profit producing!

In addition to portable pH meters, Cambridge makes line-operated Direct Reading pH Indicators and Recorders for permanent installation. They are accurate, stable and assure continuous and trouble-free performance. Either the Recorder, Indicator or both, may be located at any reasonable distance from one or several sampling points. The Glass Electrodes are placed in vapor-tight housings of clog-free sampling chambers.

Send for Bulletin No. 910 T

CAMBRIDGE pH EQUIPMENT

CAMBRIDGE INSTRUMENT CO., INC.

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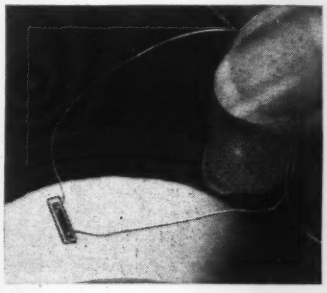
PIONEER MANUFACTURERS OF PRECISION INSTRUMENTS

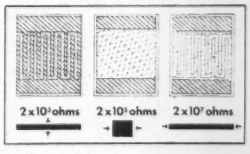
For more information circle **141** on inquiry card.

Kodak Ektron Detector...



A unique lead sulfide photosensitive resistor with the following characteristics:

- Response extends from 0.25 microns to 3.5 microns with maximum sensitivity at 2.2 microns in the infrared
- High signal-to-noise ratio in infrared
- Signal response is almost independent of size of sensitive area
- Unaffected by vibration, small in size
- Available in complex and exact arrays and mosaics



For a booklet giving detailed information on Kodak Ektron Detectors, write Military and Special Products Sales,

EASTMAN KODAK COMPANY
Rochester 4, N. Y.

Kodak

For more information circle **140** on inquiry card.

Whatever your relay needs may be, it will pay you to contact Comar. Electrical characteristics, sizes and mountings are tailor-made to exactly fit your requirements. Precision-engineered, easier to install, more efficient in operation. Send specifications for our recommendations and prices.

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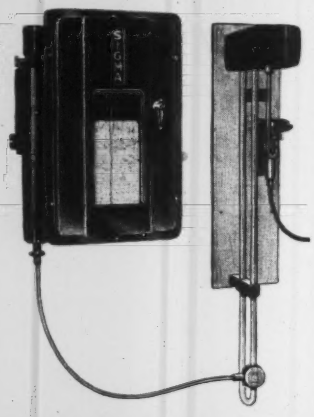
CALORIMETERS
Accurately RECORD calorific values of gases from 80 B.t.u.'s and up

- Provide reliable, trouble-free service
- Require little maintenance
- Simple in design
- Ruggedly built
- Free from continuously moving parts—except for chart drive
- Low in cost



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COSA CORPORATION
405 Lexington Ave., New York 17
NATIONAL REPRESENTATIVES FOR SIGMA INSTRUMENT CO., ENGLAND

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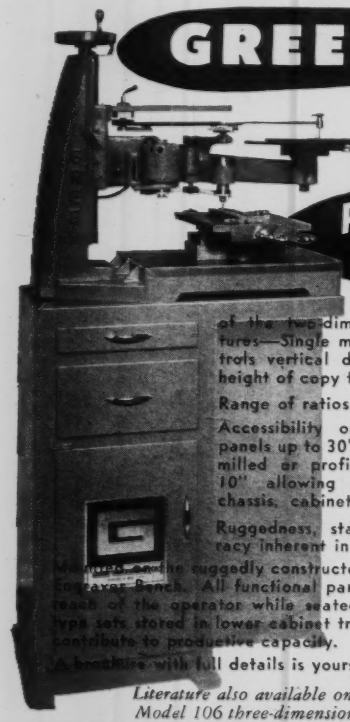
GREEN
Model D-2
Pantograph Engraver



Unique design of the two-dimensional Model D-2 features—Single micrometer adjustment controls vertical depth of cut, and adjusts height of copy table and pantograph.

Range of ratios from 2 to 1 to infinity!

Accessibility on three sides permitting panels up to 30" diameter to be engraved, milled or profiled. Vertical range over 10" allowing operations on complete chassis, cabinets or other bulky objects.

Ruggedness, stability and precise accuracy inherent in construction.

Mounted on the ruggedly constructed heavy duty steel Green Engraver Bench. All functional parts are conveniently within reach of the operator while seated. Accessibility of master type sets stored in lower cabinet trays, tools and accessories contribute to productive capacity.

A brochure with full details is yours upon request.

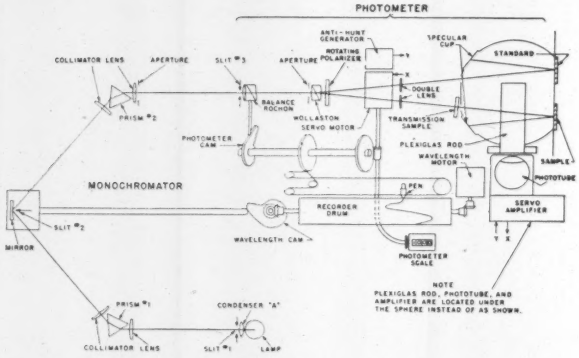
Literature also available on the smaller Model 106 three-dimensional engraver.

GREEN INSTRUMENT COMPANY
383 Putnam Ave., Cambridge, Mass.

For more information circle **144** on inquiry card.

Recording Spectrophotometer

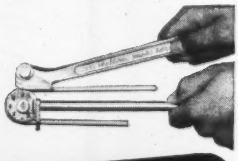
The recording spectrophotometer is useful in any industry where a colored product is manufactured. By comparing a spectrophotometric curve of a particular pigment against a curve of the desired color, a colorist can deter-



mine the exact pigment to add in order to attain a specific color . . .

Illustration shows the method of measurement on the recording spectrophotometer. The light from the projector lamp is dispersed by prism No. 1. The slit and mirror select a band of light about 10 millimicrons wide. This mirror and slit are driven by the wave-length motor through a cam system so that the spectrum is continuously scanned. A second cam system varies the mechanical width of the slit so that the 10 millimicron band is kept constant throughout the entire spectrum. This band of light is further dispersed by prism No. 2 and trimmed by slit No. 3 to assure spectral purity . . . The servo motor rotates the Rochon prism which changes the light intensity on the standard with respect to the sample by actually varying

IMPERIAL *BLUE DOT* TUBE BENDERS



Bend hard or soft tubing. Form neat accurate bends to short radius. Calibrated. ***No. 364-FH*** individual benders for each size of tubing 3/16" to 3/4" O.D. Also many other models.

Avoid Lost Time and Grief
with modern, efficient
IMPERIAL
TUBING TOOLS

IMPERIAL FLARING TOOLS
All types, for making 45°, 37° and double flares . . . on copper, aluminum, steel and stainless steel tubing. ***No. 500-F*** Flaring Tool illustrated, makes 45° flares and then burnishes them.

IMPERIAL HI-DUTY TUBE CUTTER
Free wheeling ball bearing action. Roller type with flare cut-off groove. Retractable reamer. ***No. 274-F*** for 1/8" to 1" tubing. Other models. Also sawing vises.

Ask for Catalog No. 3011

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In Canada: 334 Lauder Ave., Toronto, Ontario

IMPERIAL — Industry's Most Complete Line of Tube Fittings and Tubing Tools

For more information circle **145** on inquiry card.

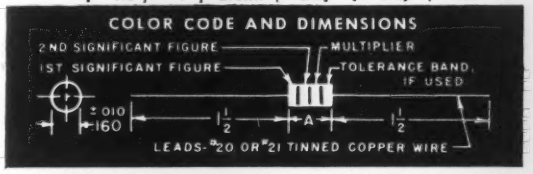
the intensity of the beams . . . Measurement is always made at the point of the zero voltage signal so that it is independent of the characteristics of the phototube, lamp, or amplifier. (*From new 8-page Bulletin GEC-307B, including extensive bibliography on Colorimetry, General Electric Co., Apparatus Sales, Schenectady 5, N. Y.*)

For this literature circle **410** on inquiry card.

Resistor-Capacitor Chart

Stackpole "GA" fixed composition capacitors . . . are now available in an expanded range of values from 0.10 to 10.0 uuf—all with standard RETMA 3 or 4 band color code . . . (46 RETMA Values).

Capacity in μμf Standard Values in			Color Bands			Max. Dim. "A"
20%	10%	5%	1st	2nd	3rd	
.10	.10	*	Brown	Black	Gray	.330
	.12	*	Brown	Red	Gray	.330
.15	.15	*	Brown	Green	Gray	.330
	.18	*	Brown	Gray	Gray	.330



Standard resistance ratings have been carefully selected to cover every circuit requirement while avoiding costly and unnecessary overlapping of values. All Stackpole ½-, 1-, and 2-watt resistors are regularly applied in each of the ranges and tolerances indicated . . .(269 RETMA values meet every modern circuit need) . . . (*From new 8" x 11" Plastic Table, Electronic Components Div., Stackpole Carbon Co., St. Marys, Pa.*)

For this literature circle **411** on inquiry card.

Your kind of . . .

Solenoid Valves

There *IS* something better in solenoid valves—the new Marsh Electrimatic. Bodies machined from solid brass stock mean extra strength, greater dependability. Coils are moisture and frost proof. Valves are tight seating, smooth, positive, quiet. Types for wide range of application: direct acting—or pilot operated for large capacity.

. . . Outline your conditions and we will tell you how we can help you with your Solenoid problems.

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Sales affiliate of Jas. P. Marsh Corp.
Dept. 42, Skokie, Ill. • Marsh Instr & Valve Co. (Can.) Ltd.
8407 103rd Street, Edmonton, Alberta, Canada

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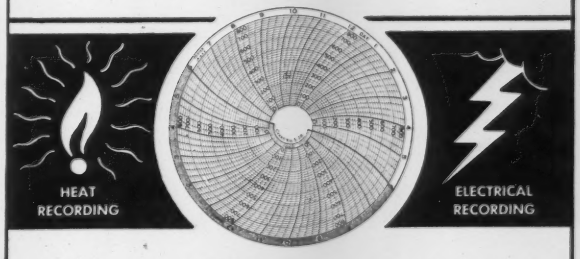
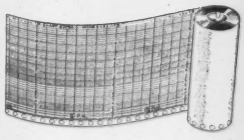
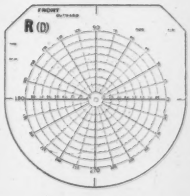
CHARTS of all types







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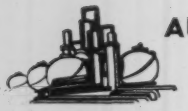
INSTRUMENTS and AUTOMATION

New Literature



AUTOMATION

Process Regulators, Valves. New 8-page Catalog 56 C presents 27 models of maker's line of reducing, relief, and control valves, temperature regulators and governors.—Atlas Valve Co., 280 South St., Newark 5, N. J.

Circle **412** on inquiry card.

Instrument Panels. New 16-page product specification Bulletin G71-7 illustrates and describes maker's standardized instrument panels and accessory equipment.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

Circle **413** on inquiry card.

Potentiometer Controllers. New 2-page Bulletin F-7298-1 describes maker's series 150 non-indicating electronic "Amplitrol" potentiometer controllers.—Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.

Circle **414** on inquiry card.

Production Line Flow Control. New 4-page Bulletin 25 describes maker's "Line Flow Control," a sensing device to detect magnetic metals without actual physical contact. Applications are described in canning, bottling, etc. —Peerless Equipment Co., 111 Ortega Ave., Mountain View, Calif.

Circle **415** on inquiry card.

Transportation Control. New 16-page illustrated Bulletin 164 describes opportunities in transportation control engineering.—Union Switch & Signal, Swissvale, Pa.

Circle **416** on inquiry card.

Hydraulic Positioning Control. New 5-page Bulletin 27 and 2-page Price List I-8 present maker's "Hydra-Trols" which are self-contained, manual-hydraulic positioning devices with immediate synchronization in either direction.—Crown Controls Div., Trimount Instrument Co., 3119-21 West Lake St., Chicago 12, Ill.

Circle **417** on inquiry card.

VALVES

Control Valves. New 20-page catalog presents design theory, operating principle, stem force factors, mechanical operation and capacities and rangeability of maker's "valves for difficult jobs" using ball seat.—P-K Industries, Inc., 27 Porete Ave., North Arlington, N. J.

Circle **418** on inquiry card.

Control Valves. New 6-page Bulletin 561 describes maker's new line of "Quick-As-Wink B-Type" air and hydraulic control valves which feature solenoid-operated pilot valve and high flow capacity.—C. B. Hunt & Son, Inc., Salem, Ohio.

Circle **419** on inquiry card.

Valves. New 152-page Catalog 55 describes the maker's services and valves for power plant, oil industry, marine and industrial service. Includes free-flow reverse-current valves, relief valves, nonlubricated plug valves, pressure-regulating valves, etc.—Atwood & Morrill Co., Salem, Mass.

Circle **420** on inquiry card.

Butterfly Valves. New 2-page Specification Sheet RM-1000 describes maker's V-port butterfly valves engineered for precise control of gas or air flow.—Hagan Corp., Pittsburgh 30, Penna.

Circle **421** on inquiry card.

MOTORS, SERVOS

D-C Motors. New 4-page Bulletin F-4344-3 describes maker's permanent-magnet d-c motors, giving specifications and dimensions.—Barber-Colman Company, Rockford, Ill.

Circle **422** on inquiry card.

Servo Kits. New 16-page Bulletin TDS-1110 describes maker's "Servoboard" electro-mechanical assembly kits, for use in control or guidance systems, motor drives etc.—Servo Corporation of America, New Hyde Park, N. Y.

Circle **423** on inquiry card.

Speed Reducers. New 2-page bulletin presents maker's Model SW-1 worm-and-gear speed reducers for fractional-horsepower motors.—Rampe Manufacturing Co., Cleveland 10, Ohio.

Circle **424** on inquiry card.

TEMPERATURE

Protected Thermocouples. New 14-page Bulletin 5 presents maker's miniature protected thermocouples designed for use in highly corrosive gases and liquids.—Thermo Electric Co., Inc., Saddle River Township, Rochelle Park Post Office, Saddle Brook, N. J.

Circle **425** on inquiry card.

Data Chart. New 2'x3' engineering data wall chart provides tables on decimal equivalents, temperature conversion, wire size, current ratings, and mechanical and electrical conversion tables.—Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

Circle **426** on inquiry card.

Superheated Steam Temperature Control. New 6-page Bulletin MSA-119 "The Charts Tell the Story," presents maker's system for "Superheated Steam Temperature Control by Hagan."—Hagan Corp., Hagan Building, Pittsburgh 30, Pa.

Circle **427** on inquiry card.

Radiation Pyrometers. New 8-page AIEE preprint "Two New Total Radiation Pyrometers" describes two infared pyrometers.—Servo Corporation of America, 20-20 Jericho Turnpike, New Hyde Park, L.I., N. Y.

Circle **428** on inquiry card.

Thermostat Metal. New 6-page Technical Data Sheet 401 describes maker's beryllium copper and "ASC-3" thermostat metal.—American Silver Co., Inc., 36-07 Prince St., Flushing 54, N. Y.

Circle **429** on inquiry card.

Power Transistor Thermometer. New 2-page bulletin describes maker's power transistor thermometer for use with germanium transistors.—B & B Engineering Associates, R.F.D. No. 1, Concord, N. H.

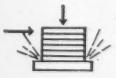
Circle **430** on inquiry card.

Thermocouple Reference Junction. New 2-page bulletin describes and illustrates maker's "RJ Series" thermocouple reference junction which provides a thermostatically controlled temperature reference for multi-channel thermocouple systems.—Pace Engineering Co., 6914 Beck Ave., North Hollywood, Calif.

Circle **431** on inquiry card.

Temperature Test Cabinet. New 2-page bulletin presents specifications of maker's atmosphere control cabinet, "Model 15-CF Cyclamatic."—Atmosphere Control Co., Inc., 5315 Chester Ave., Phila. 43, Pa.

Circle **432** on inquiry card.



PRESSURE, WEIGHT

Rupture Discs. New 4-page Catalog 77-31 presents maker's "Model D and DV" rupture discs for "tough" applications and protective features of maker's safety heads.—Black, Sivalls & Byrson, Inc., Kansas City, Missouri.

Circle **433** on inquiry card.

Pressure Tranducer. New 2-page bulletin describes maker's "Model P1" magnetic-reluctance-type pressure tranducer made in ranges from ±¼ to ±100 psi scale.—Pace Engineering Co., 6914 Beck Ave., North Hollywood, Calif.

Circle **434** on inquiry card.

Force Control Switch. New 4-page Bulletin 28-E presents prices and capacities of maker's force control switch, which uses switches and U-beams.—W. C. Dillon & Co., Inc., 14620 Keswick St., Van Nuys, Calif.

Circle **435** on inquiry card.

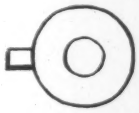
Bagging Scale. New 2-page Bulletin 6041 describes design, operation and key features of maker's new auto-

matic bagging scale.—Richardson Scale Co., Van Houten Ave., Clifton, N. J.

Circle **436** on inquiry card.

Dynamometer Scales. New 2-page bulletin presents maker's new push-pull dynamometer scales.—John Chatillon & Sons, New York 38, N. Y.

Circle **437** on inquiry card.



FLOW

Electro-Caloric Flowmeter. New 4-page bulletin describes function, construction and operation of maker's electro-caloric flowmeter that measures mass rate of flow via heat-transfer technique.—Industrial Development Laboratories, Inc., 17 Pollock Ave., Jersey City 5, N. J.

Circle **438** on inquiry card.

Flow Transmitter. New 6-page Bulletin CP 22-6A presents specifications and illustrations of maker's flow transmitter.—Bailey Meter Company, 1060 Ivanhoe Road, Cleveland 10, O.

Circle **439** on inquiry card.

Flow Transmitter. New 4-page Bulletin MYP-501 describes operation and maintenance of a Bristol transmitter installed in a ring-balance meter.—Hagan Corp., Pittsburgh 30, Penna.

Circle **440** on inquiry card.

Multi-Stage Flowrator. New 8-page Catalog 10-A-34 presents maker's line of multi-stage, variable area "Flowrator" meters designed primarily for aircraft fuel flow testing and other high-accuracy flow rate indication.—Fischer & Porter Co., Hatboro, Pa.

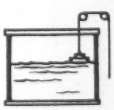
Circle **441** on inquiry card.

Chlorinators. Two new 8-page Bulletins (25.110 and 25.100) describe and illustrate maker's "series A-712 and A-711" V-notch chlorinators featuring a new concept in chlorine flow control—the V-notch variable-orifice.—Wallace & Tiernan Inc., 25 Main Street, Belleville 9, N. J.

Circle **442** on inquiry card.

Air Velocity Meter. New 2-page Bulletin B-6 describes maker's "No. 400" air velocity meter for simultaneous indication of air velocity and static pressure in fan systems, filter systems, etc.—F. W. Dwyer Mfg. Co., P.O. Box 373, Michigan City, Ind.

Circle **443** on inquiry card.



LEVEL

Level Control. New 36-page Bulletin F-4 describes and illustrates maker's "Level-Trol" line of liquid level controllers featuring the torque-tube principle.—Fisher Governor Co., Marshalltown, Iowa.

Circle **444** on inquiry card.

Level Systems. New 8-page Bulletin AD-404 describes maker's new thermistor-type liquid-level sensing system which operates a lamp or controls a pump when gasoline or other

THE MARK OF QUALITY

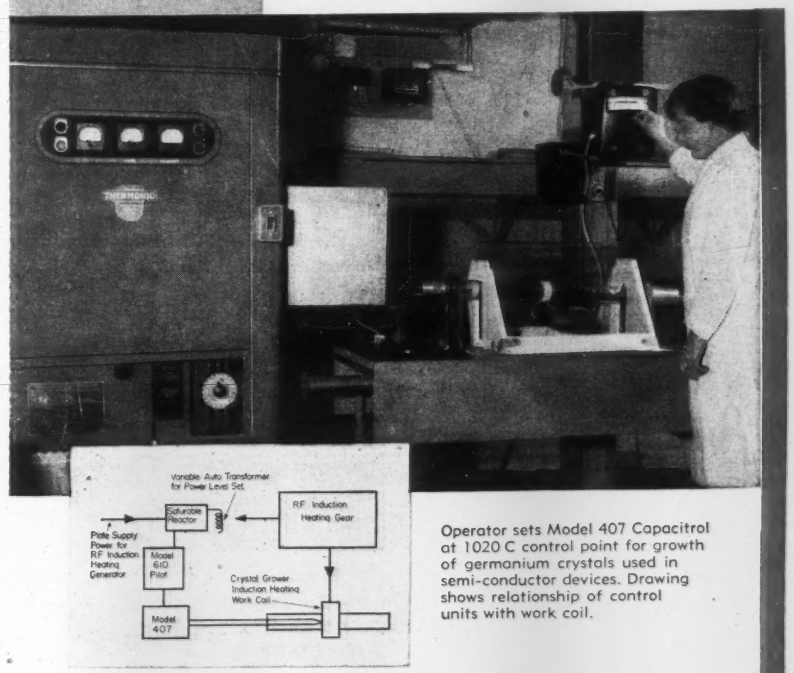
BARBER COLMAN

Wheelco Instruments

Thermal shock eliminated . . .

Crystal growth facilitated . . .

By Wheelco proportioning temperature control!


Variable Auto Transformer for Power Level Set
Saturable Reactor
RF Induction Heating Gear
Plate Supply Power for RF Induction Heating Generator
Model 610 Pilot
Crystal Grower Induction Heating Work Coil
Model 407

Operator sets Model 407 Capacitrol at 1020 C control point for growth of germanium crystals used in semi-conductor devices. Drawing shows relationship of control units with work coil.

"On-off" temperature control is unsuited to the growth of germanium crystals. Harsh thermal shock imparts faults into the crystals, producing poor lattice structure. Deposition of the conductivity determining additive is erratic, rather than smooth and uniform. But, manufacturers have discovered the advantages inherent in the use of Wheelco Model 407 Capacitrols with saturable core reactors. These superb instruments provide the *smooth, stepless proportioning of heat input* that assures excellent crystals every time. In the case illustrated, a Wheelco Capacitrol is used with a saturable core reactor to modulate output of a radio frequency induction heating generator. Results have been most satisfactory for the transistor manufacturer. Solutions to control problems like this are an important part of the daily job of your Wheelco field engineer. Why not call him in to help with *your* control problems?

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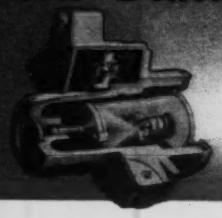
For more information circle **148** on inquiry card.

Chroluminum* Coating by Evaporated Protects Delicate Control Instrument



Leeds & Northrup Co. of Philadelphia solved a critical problem in their Rayotube® heat radiation measurement and control device with Evaporated mirror coatings. Radiant energy, entering through the window on the front, is reflected by a double mirror system back to a thermopile, which translates relative heat levels into voltage which can be measured by control instruments. A circular Chroluminum* coating and a precision-coated (±0.005 tolerance) ring on the outside diameter of the glass accurately controls the area through which heat may enter the device. A coated secondary mirror focuses energy from the primary mirror onto the thermopile. "The coatings are of excellent quality," says Leeds & Northrup's inspection department. "We are very pleased with the results." Evaporated's experienced engineers may be able to help you with your instrumentation problems, too. Write us, outlining your needs.

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Ithaca, New York

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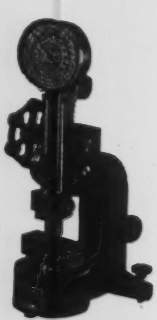
done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 50 years.

In general use for specification purposes. Simple, sturdy. Comparatively inexpensive.



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For more information circle **150** on inquiry card.

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RFL Model 983
OPERATES OVER WIRE CIRCUIT OR MICROWAVE

- **2-Way Clear Voice and Reliable Control**
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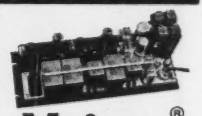

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Boonton, New Jersey, U. S. A.

For more information circle **151** on inquiry card.

NEW LITERATURE

liquid is above or below a certain level.—Simmonds Aerocessories, Inc., 105 White Plains Rd., Tarrytown, N. Y.

Circle **445** on inquiry card.

Level Control. New 2-page leaflet describes maker's "Cat. 140" sensitive liquid-level control diaphragm-switch action for applications requiring extreme low liquid level or where level height must be maintained with accuracy.—Henry G. Dietz Co., 12-16 Astoria Blvd., L.I. City 2, N. Y.

Circle **446** on inquiry card.

LABORATORY

Test Laboratory Services. New 72-page Bulletin form-101 outlines services and facilities of testing laboratory, including chemical, electrical, electronic, mechanical, physical, photometric, radiometric and colorimetric testing.—Electrical Testing Laboratories, Inc., 2 East End Ave., New York 21, N. Y.

Circle **447** on inquiry card.

Lab Test Apparatus. New 128-page Catalog 56 contains descriptions and illustrations of over 1350 items of maker's apparatus for engineering tests of soils, concrete, asphalt and construction materials. Includes piezometers, specific gravity instruments, thermometers, test machines, etc.—Soiltest Inc., 4711 W. North Ave., Chicago 39, Ill.

Circle **448** on inquiry card.

Laboratory Suppiles. New 16-page issue of "The Palo Retort" (Spring '56) presents line of laboratory supplies and scientific instruments.—Palo Laboratory Supplies, Inc., 81 Reade St., New York 7, N. Y.

Circle **449** on inquiry card.

Laboratory-Balance Weights. New 2-page bulletin describes maker's new "Sto-A-Weigh" weight set.—Ohaus Scale Corp., Union, N. J.

Circle **450** on inquiry card.

Pore Analysis. New 2-page Bulletin 2282 describes maker's "Porosimeter" which performs a complete pore structure analysis of any porous material.—American Instrument Co., Inc., Silver Spring, Md.

Circle **451** on inquiry card.

Soil Density Tests. New 2-page bulletin describes maker's "Volumeasure CN-980" for field or laboratory in-place density tests of soils.—Soiltest Inc., 4711 W. North Ave., Chicago 39, Ill.

Circle **452** on inquiry card.

Tension Test. New 6-page folder describes maker's "Model CET" tester for tension, compression and hysteresis in range 0-2,000 lb.—Scott Testers, Inc., 45 Blackstone St., Providence, R. I.

Circle **453** on inquiry card.

Concrete Tester. New 6-page folder describes maker's concrete tester "Model CT-711" and accessory equip-

ment.—Soiltest Inc., 4711 West North Ave., Chicago 39, Ill.
Circle **454** on inquiry card.

Distilling Unit. New 2-page bulletin describes maker's Cargille-Wagner distilling unit "No. CW-656" which has no tripod, no ring stand and no clamps.—Cargille Scientific Inc., 117 Liberty St., New York 6, N. Y.
Circle **455** on inquiry card.

ANALYTICAL

Oxygen Recorders. New 4-page Data Sheet 643 (5) describes maker's oxygen-recording equipment for open-hearth furnaces.—Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 30, Pa.
Circle **456** on inquiry card.

Infrared Spectroscopy, Data Processing. New 8-page "Beckman Bulletin No. 18" features articles on infrared spectroscopy, data processing, and analytical and process instrumention.—Scientific Instruments Div., Beckman Instruments Inc., Fullerton, Calif.
Circle **457** on inquiry card.

Magnetic-Field Control System. New 4-page brochure describes maker's "Model C-1" magnetic field control system for stabilization and control of electromagnetic fields in mass spectrometers, etc.—Nuclear Magnetics Corp., 154 Boylston St., Boston, Mass.
Circle **458** on inquiry card.

Chromatography. New 4-page bulletin presents maker's "Model 1111A" chromagraph for analysis of gases and liquids by adsorption and partition techniques.—Hallikainen Instruments, 1341 Seventh Street, Berkeley 10, Calif.
Circle **459** on inquiry card.

Viscometer. New 4-page bulletin describes maker's new Model STI shearing disc viscometer.—Scott Testers, Inc., 101 Blackstone St., Providence, R. I.
Circle **460** on inquiry card.

GAGING

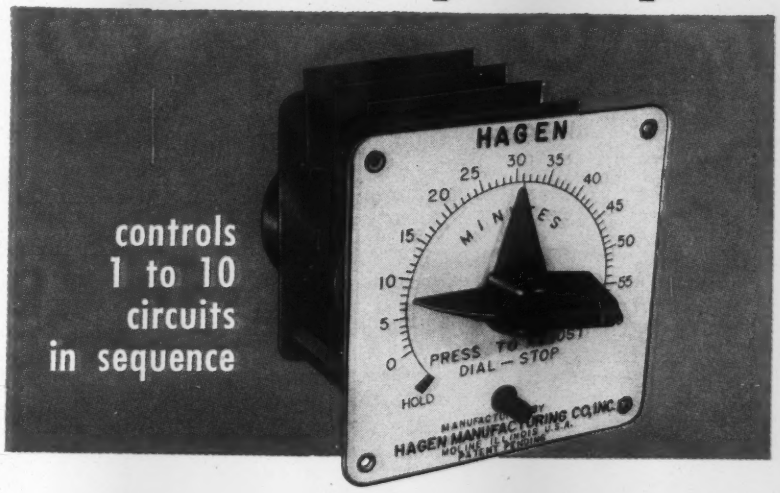
Dial Indicator. New 2-page Bulletin 656 describes maker's new "Emre" 0.00005" dial indicator and the new "Master" dial indicator checker.—Petz-Emery Inc., Pleasant Valley, New York, N. Y.
Circle **461** on inquiry card.

TIME, COUNT

Proximity Transducer Systems. New 4-page Bulletin CPP356 describes maker's proximity transducer systems for counting up to 60,000 metal objects per minute, detecting ferrous and non-ferrous metals, indicating rate of travel etc.—Electro Products Laboratories, 4501 Ravenswood Ave., Chicago 40, Ill.
Circle **462** on inquiry card.

Pulse Time Measurement. New 8-page bulletin presents maker's "Marker-Pulser" for measuring delay lines,

NEW HAGEN
hand set
time delay relay



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No danger of over-timing when you repeat a process several times — each with the same timing. On the first run, operator simply presses the stop release button and sets the adjustable stop (both shown in blue) at the desired time . . . then turns the pointer as far to the right as it will go . . . it can't go beyond the stop. Thus the setting is always correct — on the first and all subsequent runs.

A synchronous motor returns the cam shaft to "O" position, tripping switches in accordance with time settings. The process is stopped automatically.

A wide selection of snap-action switches is available . . . as well as cam combinations. The Hagen Hand Set Time Delay Relay Model 73 is the answer to controlling solenoid valves in an industrial process, starting a group of motors in sequence, for pump controls, and many other uses.

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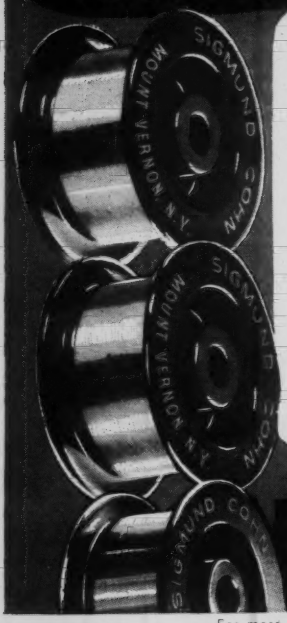

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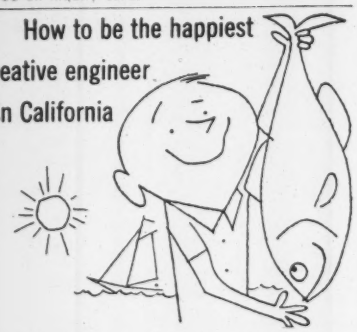

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NEW LITERATURE

[redacted] filters, amplifiers, networks etc.—Brubaker Electronics, Inc., 3652 Eastham Drive, Culver City, Calif.

Circle **463** on inquiry card.

Cycle Timer. Two new 2-page application data sheet presents application data on maker's repeat cycle timer "Model 1"—including uses for refluxing, spot welding, heat cycling, mixing machines, etc.—G. C. Wilson & Co., Huntington, W. Va.

Circle **464** on inquiry card.

VIBRATION

Vibration Meter. New 4-page Bulletin 1566 describes maker's lightweight, transistorized vibration meter "Type 1-128."—Consolidated Electrodynamics Corp., 300 North Sierra Madre Villa, Pasadena, Calif.

Circle **465** on inquiry card.

Vibration Detector. New 8-page bulletin describes maker's "Model 5 Vibraswitch" malfunction detector for protecting rotating equipment.—Bell Corp., Richmond 26, Va.

Circle **466** on inquiry card.

Vibrodyne Balancer. New 12-page Bulletin 53 presents maker's "Vibrodyne" balancer for in-place analysis and correction of unbalance.—Tinius Olsen Testing Machine Co., Easton Road, Willow Grove, Pa.

Circle **467** on inquiry card.

OPTICAL

Infrared Glass. New 4-page bulletin describes optical, chemical, physical and thermal properties of maker's "Servofrax" arsenic trisulfide glass.—Servo Corporation of America, New Hyde Park, N. Y.

Circle **468** on inquiry card.

Infrared Transmitting Materials. New 4-page brochure presents comparative information on 15 infrared transmitting materials suitable for use as optical elements.—Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, L.I., N. Y.

Circle **469** on inquiry card

Turbidity Recorder. New 2-page engineering Data Sheet AED 208-8 describes maker's continuous turbidity detector recorder for beer.—The Foxboro Co., Foxboro, Mass.

Circle **470** on inquiry card.

Photoprocessor. New 4-page bulletin describes maker's automatic "Photoprocessor" for precisely controlled processing of research and analytical photographic emulsions.—Jarrell-Ash Co., 26 Farwell St., Newtonville, Mass.

Circle **471** on inquiry card.

Etching. New 4-page bulletin presents maker's "Photo-Wrinlay" process for applying permanent markings to panels, dials, nameplates etc.—Photo Chemical Products, 479 Walton Ave., New York, N. Y.

Circle **472** on inquiry card.

Surveying Problems. New 16-page Notebook 15M-4-56 "Tips from the Surveyor's Notebook" is a new edi-

lection of articles on unusual surveying problems and their solutions.—W. & L. E. Gurley, Troy, N. Y.
Circle **473** on inquiry card.

Magnifiers. New 16-page booklet describes and illustrates maker's magnifiers for shop, laboratory, darkroom, and office.—Bausch & Lomb Optical Co., Rochester 2, N. Y.
Circle **474** on inquiry card.

Phase Contrast Microscopy. New 16-page Catalog D-104 describes and illustrates maker's phase contrast accessories for microscopes and provides general background to the field. —Bausch & Lomb Optical Co., Rochester 2, N. Y.
Circle **475** on inquiry card.

Cameras. Seven 2-page bulletins describe maker's "Design 200-p" 16-mm magazine pulse camera, "Design 70-KRM" 16-mm motion-picture camera, "Design 71-QM" 35-mm motion-picture camera, "Design 71-KM" 35-mm motion-picture camera, "Design 71-MM" 35-mm motion-picture camera, "Design 71-RM" 35-mm motion-picture camera and "Design 198" portable splicers.—Bell & Howell, 4515-17 Sepulveda Blvd., Sherman Oaks, Calif.
Circle **476** on inquiry card.

Photographic Instruments. New 8-page bulletin describes and illustrates maker's "500" high-speed motion-picture camera and accessories.—Triad Corp., Sherman Oaks, Calif.
Circle **477** on inquiry card.

Photoelectric Relays. New 2-page bulletin presents maker's new miniature photoelectric relays.—Tri-Tronics Co., 2607 St. Charles Road, Bellwood, Ill.
Circle **478** on inquiry card.

COMPUTERS

Digital Computer. New 12-page bulletin and 8-page reprint describe maker's "LGP-30" serial, single address, fixed point, binary, stored program digital computer.—Librascope, Inc., 808 Western Ave., Glendale, Calif.
Circle **479** on inquiry card.

Operational Equations. New 12-page data file 120 presents "Operational Equations for Programming Electronic Analog Computers."—Berkeley Div. of Beckman Instruments Inc., 2200 Wright Ave., Richmond 3, Calif.
Circle **480** on inquiry card.

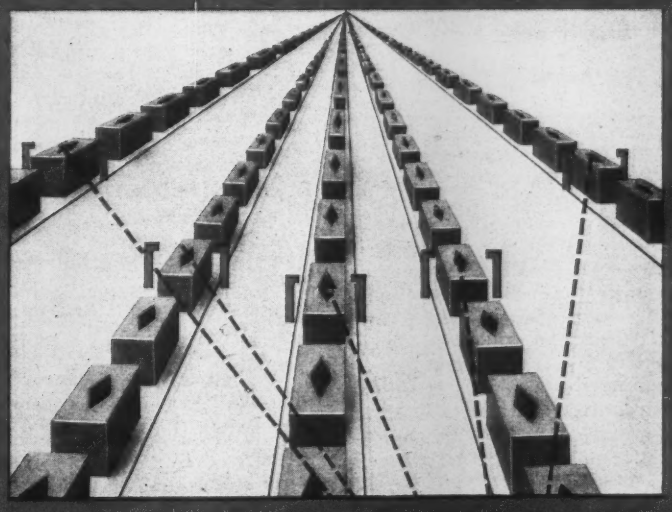
Recorders Converters. New 10-page Bulletin PBX-75001-2 describes maker's magnetic tape and perforated tape "MTM Transrecorder" and "MTM and MTP" tape converters.—Remington Rand Univac, 1902 West Minnehaha Ave., St. Paul W4, Minn.
Circle **481** on inquiry card.

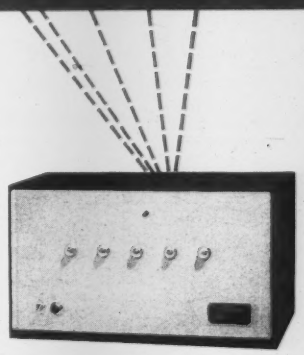
Gravity Anomaly Simulator. New 2-page Bulletin GM-203 describes maker's gravity anomaly simulator which simulates effects on the earth's gravity field of a subsurface body of anomalous density.—Houston Technical Laboratories, 2424 Branard, Houston 6, Texas.
Circle **482** on inquiry card.

Computer Discs. New 4-page bulletin presents maker's line of pre-

MULTI PRODUCTION LINES NEED:

POST multi-channel counters





MC—MULTI CHANNEL INPUT UNIT

New . . . Post's multi-channel counters answer industry's need for a "total" count from several production lines *at any given moment.* Working in conjunction with a Post DECITRON electronic counter, the multi-channel system requires a photohead for each production line . . . relayed signals are tabulated by the MC and transferred to the counter instantly for visual evidence of "total".

Post also manufacture a variety of photo electric relays and industrial timers ideally suited to multi-production control systems. Write for descriptive literature.

POST

Electronic Products Division

POST MACHINERY CO.

163 Elliott Street

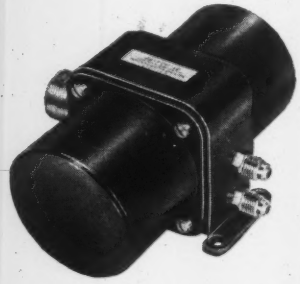
Beverly, Mass.

For more information circle **154** on inquiry card.

PRESSURE TRANSDUCERS

featuring Fairchild accuracy and reliability

New 2" and 3" pressure transducers introduce a new line of Fairchild controls, featuring all the characteristics of precision, reliability and quality that are identified with Fairchild potentiometers. Now, pressure transducers will be available to you in a wider range of resistances in either linear or functional, single or dual potentiometer output elements.



The unit shown features two pressure-sensitive diaphragm elements which actuate two precision potentiometers through a dynamically-balanced, stable mechanical linkage. Variations of size, conformation and pressure ranges for measurement of differential, absolute or gauge pressures are also available. For complete information, write Fairchild Controls Corp., Components Division, 225 Park Avenue, Hicksville, L. I., N. Y.; **West Coast:** 6111 E. Washington Blvd., Los Angeles, Calif., Dept. 140-70B.

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PRECISION POTENTIOMETERS
PRESSURE TRANSDUCERS

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★ *of all Nylon* for severe conditions
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SCREWS and NUTS
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FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY

TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

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For more information circle **157** on inquiry card.

NEW LITERATURE

cision photomechanical dials, divided circles, complex wave forms, digital computer coding discs and sine wave frequency standards made by optical generation of dial graduations.—Precision Photomechanical Corp., 176 So. Van Brunt St., Englewood, N. J.
Circle **483** on inquiry card.

Magnetic Drums. New 4-page Bulletin L-7020 presents maker's magnetic drums for semi-permanent storage of data in digital computers.—Bryant Gage & Spindle Div. Bryant Chucking Grinder Co., P. O. Box 620, Springfield, Vermont.
Circle **484** on inquiry card.

COMBUSTION

Combustion Test Kit. New 4-page Bulletin G-20 presents maker's combustion test kit for gas, oil or coal fired installations.—F. W. Dwyer Mfg. Co., P.O. Box 373, Michigan City, Ind.
Circle **485** on inquiry card.

Flame Control. New 12-page Bulletin CP-32 describes installation, specifications and servicing of maker's "Fireye System FP-2, Model 1012" which provides automatic starting and operating flame safeguard protection.—Combustion Control Div., Electronics Corp. of America, 77 Broadway, Cambridge, Mass.
Circle **486** on inquiry card.

Desuperheater. New 4-page Bulletin 1024 describes capabilities and specifications of maker's "Steam-Assist" desuperheater.—Copes-Vulcan Div., Blaw-Knox Co., Erie 4, Pa.
Circle **487** on inquiry card.

TUBING, AIR

Industrial Hose and Fittings. New 12-page Bulletin 174 describes and illustrates maker's industrial hose and fittings, including assembly instructions, installation planning, etc.—Aeroquip Corp., Jackson, Mich.
Circle **488** on inquiry card.

Nylon Pressure Tubing. New 8-page bulletin, four 2-page "Case Histories" and four 2-page technical bulletins describe maker's "Nylaflow" nylon pressure tubing for lubrication lines, hydraulic lines, process lines, etc.—Polymer Corp. of Pennsylvania, Reading, Pa.
Circle **489** on inquiry card.

Wiring Duct. New 2-page bulletin presents maker's wiring duct for installation in control panels.—Taylor Electric, Inc., 15400 Dale, Detroit 23, Mich.
Circle **490** on inquiry card.

Fiberglass Tubing. New 4-page brochure describes maker's "Tuff-Tube" laminated fiberglass-epoxy tubing.—Lamtex Industries, Inc., 51 State St., Westbury, N. Y.
Circle **491** on inquiry card.

Air Filters. New 2-page Bulletin C-22AB describes and gives specifications of maker's instrument air filters and driers.—The Briggs Filtration Company, River Road, Washington 16, D.C.
Circle **492** on inquiry card.

AIRCRAFT

Rate Gryo. New 4-page bulletin presents maker's rate gyro Model 36128 and 36129, giving specifications and illustrations.—G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena, Calif.

Circle **493** on inquiry card.

Aircraft Switches. New 4-page Bulletin 137 describes maker's propeller-feathering-system switches, turbo-jet switches, generator and inverter switches.—Airite Products, Inc., 3516 E. Olympic Blvd., Los Angeles 23, Calif.

Circle **494** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

Electrical Measuring Instruments. New 20-page Monograph TM-101 presents broad cross section of entire electrical measuring instrument field, including recent instruments incorporating use of vacuum tubes and cathode-ray tubes. Traces development of galvanometers, p-m m-c movements, electrodynamometers, recording instruments, and laboratory instruments.—Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

Circle **495** on inquiry card.

Noise Generators. New 3-page bulletin introduces maker's broad-band argon noise generators and an automatic noise figure indicator.—Airborne Instruments Laboratory Inc., Mineola, N. Y.

Circle **496** on inquiry card.

Recording Galvanometers. New 4-page Bulletin CEC-1559A presents maker's 5 types of "7-300" recording galvanometers.—Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle **497** on inquiry card.

Carrier Amplifier. New 4-page Bulletin 1550 B describes maker's "Type 1-127" four-channel 20-KC carrier amplifier.—Consolidated Electrodynamics, Corp., 300 North Sierra Madre Villa, Pasadena, Calif.

Circle **498** on inquiry card.

Time Filter System. New 2-page Bulletin S-317 describes maker's "magneFILTER" system for linear or nonlinear filtering of noise from broad band energy stored on the "magneDISC" magnetic recorder.—Houston Technical Laboratories, 2424 Branard, Houston 6, Texas.

Circle **499** on inquiry card.

Attenuator. New 2-page bulletin presents maker's "Model 462" attenuator for use in laboratory or production testing work.—New London Instrument Company Inc., 82 Union St., New London 15, Conn.

Circle **500** on inquiry card.

Microvolt Ammeter and Amplifier. New 2-page bulletin describes and illustrates maker's Model 203 combination DC microvoltmeter, microammeter and amplifier.—Kay Lab, 5725 Kearney Villa Rd., San Diego 12, Calif.

Circle **501** on inquiry card.

Test Sets. New 2-page leaflet presents maker's "Model 1015, Model 35 and Model 1525A" high-voltage test sets.— Electro Devices Inc., St. Louis 13, Missouri.

Circle **502** on inquiry card.

Damping. New 2-page bulletin describes maker's "Type DM 4 Dampometer", electronic apparatus for automatic recording of logarithmic decrement and frequency of oscillations.—Oltronix, 235 Underwood Drive, Atlanta 5, Ga.

Circle **503** on inquiry card.

VSWR. New 2-page Bulletin 125-256 describes maker's band-sweeping equipment for continuous display or recording of VSWR in the region 8500 to 9600 Mc for laboratory research or production-line testing applications.—Color Television Inc., 953 E. San Carlos Ave., San Carlos, Calif.

Circle **504** on inquiry card.

Double Sheet Detector. New 2-page Bulletin 103-56 presents performance and dimensional specifications of maker's electronic double sheet detector for ferrous metals.—De-Tec-Tronic Corp., 2512 N. Halsted St., Chicago 14, Ill.

Circle **505** on inquiry card.

Oscilloscopes. New 4-page Bulletin 407 describes maker's large-screen oscilloscopes, multi-channel oscilloscopes and swept-frequency generators.— Electromec., 5121 San Fernando Rd., Los Angeles 39, Calif.

Circle **506** on inquiry card.

Direct Writing Oscillographs. New 10-page folder, including Bulletin 562 and 565, describes maker's single-channel, twin-channel and multi-channel oscillographs and operational recording accessories.—Douglas Scientific Products, Inc., 2040 Colorado Ave., Santa Monica, Calif.

Circle **507** on inquiry card.

Servo Amplifier. New 2-page bulletin describes maker's servo amplifier, "Model 1800-0100" and gives physical and electrical specifications. —M. Ten Bosch, Inc., Pleasantville, N. Y.

Circle **508** on inquiry card.

Test Equipment Calibrator. New 2-page bulletin presents maker's "Model 750" calibrator for checking accuracy of voltmeters, ohmmeters, signal generators, etc.—B & K Manufacturing Co., 3726 N. Southport Ave., Chicago 13, Ill.

Circle **509** on inquiry card.

Loading Transformer. New 2-page Bulletin 432 presents maker's "Type CL-5" loading transformer for currents to 1000 amperes.—Knopp Inc., 4224 Holden St., Oakland 8, Calif.

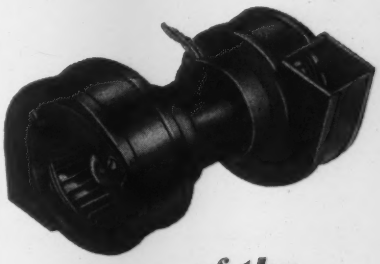
Circle **510** on inquiry card.

Receivers. New 2-page bulletin presents maker's "Type 1502" special-purpose receiver for telemetering, guided missile, radiosonde reception, etc.—Nems Clarke Inc., 919 Jesup-Blair Dr., Silver Spring, Md.

Circle **511** on inquiry card.

Oscilloscope. New 4-page bulletin presents maker's "Model 2400" series 12 channel multi-trace large screen

champion...



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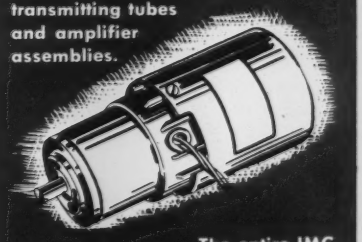

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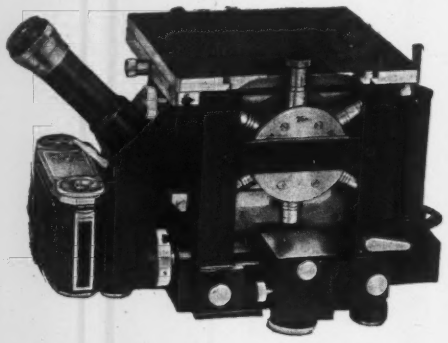

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NEW LITERATURE

oscilloscope for use in medical and industrial waveform study.—Railway Communications. Inc., 9351 East 59th St., Raytown, Missouri.
Circle **512** on inquiry card.

Phase Shifter. New 4-page Bulletin 431 describes maker's "Type Q" phase shifter, a polyphase induction type which incorporates a manually rotatable rotor.—Knopp Inc., 4224 Holden St., Oakland 8. Calif.
Circle **513** on inquiry card.

POWER SUPPLIES

Power Supply. New 2-page Bulletin 1567 describes maker's miniature power supply "Type 3-134," now available for use in aircraft or ground-station facilities.—Consolidated Electrodynamics Corporation, 300 N. Sierra Madre Villa, Pasadena, Calif.
Circle **514** on inquiry card.

Magnetic Components. New 2-page bulletin presents maker's magnetic components and magnetically regulated power supplies.—Magnetic Research Corp., 200 Center St., El Segundo, Calif.
Circle **515** on inquiry card.

Power Supplies. New 4-page Bulletin B 356 presents maker's voltage regulated power supplies.—Kepco Laboratories, 131-38 Sanford Ave., Flushing 55, N. Y.
Circle **516** on inquiry card.

Power Supply. New 2-page bulletin describes maker's "Permavolt" cell

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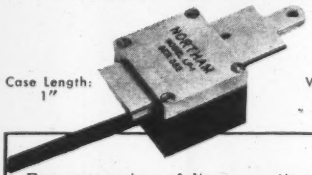

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For more information circle **163** on inquiry card.

which provides a direct-current power supply which replaces 1.5-volt dry-cell batteries in self-balancing potentiometers, resistance thermometers and strain gage bridges.—Pace Engineering Co., 6914 Beck Ave., North Hollywood, Calif.
Circle **517** on inquiry card.

Rotary Converters. Five new 8-page maintenance and parts catalogs (256, 656, 156, 354 and 456) describe maker's rotary converter, power supply, dynamotor, etc., and provides repair policy, parts list and lists prices.—Carter Motor Co., 2644 N. Maplewood Ave., Chicago 47, Ill.
Circle **518** on inquiry card.

Power Supplies. New 5-page technical bulletin describes, gives operation and specifications of maker's transistorized regulated power supplies, "Series 50T, 100T and 200T".—Electronic Research Assoc., Inc., 67 E. Centre St., Nutley, N. J.
Circle **519** on inquiry card.

ELECTRONIC COMPONENTS

Voltage Stabilizing Transformer. New 12-page Bulletin GED-2987 presents maker's voltage stabilizing transformer. Includes selection guide, application and specification chart.—General Electric, Schenectady 5, N. Y.
Circle **520** on inquiry card.

Variable Transformer. New 22-page Catalog A56 describes maker's "Adjust-A-Volt" variable transformers in auto-isolated and metered models for bench and panel mounting.—Standard Electrical Products Co., 2240 E. Third St., Dayton, Ohio.
Circle **521** on inquiry card.

Waveguide Components. New 4-page catalog describes maker's waveguide components for use from 26,100 to 39,500 Mc (8-10 mm) microwave band.—Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.
Circle **522** on inquiry card.

Transistor Circuits. New 2-page bulletin describes maker's new intercompatible transistor plug-in pulse circuits.—Tripl-T Electronics Co., Box 352E, Pasadena, Calif.
Circle **523** on inquiry card.

Printed-Circuit Lugs, Rivets. New 2-page bulletin describes maker's "Microminiature" terminal lugs and rivets for instrument, electronic and printed circuit applications.—Circon Component Co., Santa Barbara Municipal Airport, Goleta, Calif.
Circle **524** on inquiry card.

Printed Circuit Connector. New 12-page brochure presents maker's expanded line of printed circuit receptacles for 1/16", 3/32" and 1/8" boards.—Electronic Sales Div., DeJur-Amsco Corp., 4501 Northern Blvd., L. I. City 1, N. Y.
Circle **525** on inquiry card.

Power Rectifiers. New 2-page Bulletin 0-0306 describes maker's selenium industrial power rectifiers.—International Rectifier Corp., El Segundo, Calif.
Circle **526** on inquiry card.

Electronic Parts. New 96-page pocket-edition replacement control guide lists electronic part replacements by part numbers including radios, televi-

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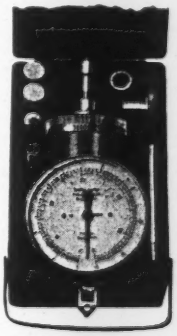

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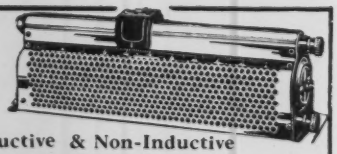

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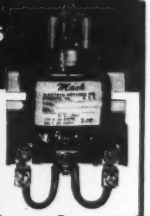

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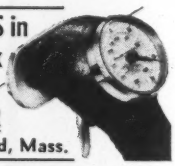

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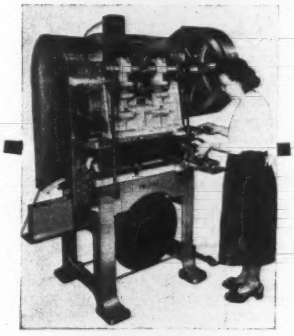

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NEW LITERATURE

sion, auto sets and audio—Price 20 cents—Centralab, Div. of Globe Union Inc., 900 Keefe Ave., Milwaukee 1, Wis.

Circle **527** on inquiry card.

Hook-Up Wires. New 2-page engineering Bulletin 1901 describes maker's "Permacode" hook-up wires rated at 600 and 1000 volt service for continuous operation over the temperature range from −90°C to +210° C.—Revere Corporation of America, Wallingford, Conn.

Circle **528** on inquiry card.

Connectors. New 4-page Bulletin PR-MC3 describes and gives specifications of maker's line of "MC" subminiature connectors for use with miniature equipment.—Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

Circle **529** on inquiry card.

Microminiature Relay. New 8-page Bulletin GEA634A describes maker's hermetically-sealed microminiature relay for airborne, shipboard and portable unit applications.—General Electric Co., Schenectady 5, N. Y.

Circle **530** on inquiry card.

Subminiature Relay. New 2-page Bulletin GEA-6412 describes maker's "2 PDT" hermetically sealed subminiature relay. Provides technical table of coil data.—General Electric Co., Schenectady 5, N. Y.

Circle **531** on inquiry card.

Capacitors. New 4-page Bulletin CC-137 describes and illustrates 8 models of maker's capacitors.—Allen D. Cardwell Manufacturing Corp., Plainville, Conn.

Circle **532** on inquiry card.

Magnetic Deflection Yokes. New 2-page bulletin presents maker's magnetic deflection yokes for 1½" neck diameter military and oscilloscope applications.—Syntronic Instruments, Inc., 170 Industrial Rd., Addison, Ill.

Circle **533** on inquiry card.

Electronic Cable. New 4-page bulletin describes maker's multi-conductor electronic cable.—Pacific Automation Products, Inc., 1000 Air Way, Glendale 1, Calif.

Circle **534** on inquiry card.

POTENTIOMETERS

Precision Potentiometers. New 20-page catalog presents maker's line of precision potentiometers, including technical data, dimensional drawings, power rating curves and sine-cosine design criteria.—The Gamewell Company, Newton Upper Falls 64, Mass.

Circle **535** on inquiry card.

Potentiometers. New 2-page bulletin describes maker's ¼" diameter potentiometers, cylinder" Type 101-A" trimmer potentiometer, and bushing mount "Type 101-B" trimmer potentiometer.—Carter Mfg. Corp., 23 Washington St., Hudson, Mass.

Circle **536** on inquiry card.

Potentiometers. New 2-page Bulletin 230 P/6/B presents maker's Model 230 "Trimpot" humidity-proof potentiometer.—Bourns Laboratories, 6135 Magnolia Ave., Riverside, Calif.

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Advertisers' Index

Acromark Company 1889
A'G'A Division of Elastic Stop Nut Corp. of America 1871
Alina Corporation 1845
Allied Radio Corporation 1877
American Chain & Cable Company 1865
American Meter Company 1700-1701
American Time Products, Inc. 1808
Amperite Co., Inc. 1828
Amthor Testing Instrument Co., Inc. 1887
Annin Company 1721
Assembly Products, Inc. 1874
Associated Spring Corporation 1755
Automatic Electric Mfg. Co. 1852

Bacharach Industrial Instrument Co. 1850
Bailey Meter Company 1736
Baker & Company, Inc. 1742, 1819, 1855
Baldwin-Lima-Hamilton Corporation 1751
Barber-Colman Company 1858
Barber-Colman Company, Wheelco Instruments Div. 1879
Beckman Instruments, Inc. 1732, 1882
Bendix Aviation Corporation 1869
Berkeley Division, Beckman Instruments, Inc. 1798
Black, Sivalls & Bryson, Inc. 1715
Bourns Laboratories 1765
Bridgeport Thermostat Division 1847
Bristol Company 1722, 1734-1735
Brooks Rotameter Company 1856
Brown Instruments Division of Minneapolis-Honeywell Regulator Co. 1727, 1728, 1729, 1730, 1752
Brush Electronics Company 1725, 1740-1741
Burgess Battery Company 1864

Cambridge Instrument Co., Inc. 1875
Chatillon & Sons, John 1839
Chemical Construction Corp. 1860
Clary Corporation 1887
Cohn Mfg. Co., Inc., Sigmund 1882
Comar Electric Company 1875
Computer Div., Bendix 1869
C. O. M. S. I. P. 1888
Consolidated Electrodynamics Corporation 1702, 1827, 1861
Cosa Corporation 1876
Crescent Insulated Wire & Cable Co. 1764
Crow Electri-Craft Corp. 1889
Curtiss-Wright Corporation 1864

Daystrom, Inc. 1698
Dialight Corporation 1742
Dietert Co., Harry W. 1847
du Pont de Nemours & Co., Inc., E. I. 1846
Dwyer Mfg. Co., F. W. 1873

Eastman Kodak Company 1875
EECO Production Company 1844
El Mec Laboratories, Inc. 1826
Electrical Testing Laboratories, Inc. 1888
ElectroData Division of Burroughs 1830
Electronic Associates, Inc. 1792
Electrons, Incorporated 1843
Ellis & Sons, Inc., George D. 1888
Engelhard, Inc., Charles 1842
Eppley Laboratory, Inc. 1724

Epsco Incorporated 1733
Evaporated Metal Films Corp. 1880

Fairchild Controls Corporation, Components Division 1884
Falstrom Company 1696
Fenwal Incorporated 1815
Fischer & Porter Co. ..... Inside Back Cover
Fisher Governor Company 1862
Foxboro Company 1708-1709, 1763

General Electric Company 1750, 1858
General Motors Corporation 1739
Giannini & Co., Inc., G. M. 1854, 1857
Goodyear Atomic Corp. 1882
Gow-Mac Instrument Co. 1866
Green Instrument Company 1876
Greiner Co., Emil 1747
Gubelman Publishing Company 1877
G-V Controls Inc. 1860

Hagen Manufacturing Company, Inc. 1881
Hammel-Dahl Company ..... Back Cover
Haydon Company, A. W. 1855
Heiland, Div. of Minneapolis-Honeywell Regulator Co. 1818
Heise Bourdon Tube Company, Inc. 1832
Heitz Inc., Karl 1845
Helicoid Gage Division 1865
Hewlett-Packard Company 1705
Hoke Incorporated 1714
Hughes Aircraft Company 1753

Illinois Testing Laboratories, Inc. 1737
Imperial Brass Mfg. Co. 1876
Induction Motors Corp. 1885
International Business Machines 1766
International Optical Co., Inc. 1888

Johnson Engineering Company, Inc., Welton V 1851
Jones Optical Works, A. D. 1873
Joy Manufacturing Company 1720

Kay Lab 1822
Kearfott Company, Inc. 1831
Kester Solder Company 1874
King Engineering Corp. 1886

Leeds & Northrup Company 1758
Lepel High Frequency Laboratories, Inc. 1837
Leslie Co. 1809
Lewis Engineering Co. 1706
Lockheed Aircraft Corporation 1853
Lynn, Robert M. 1704

Mack Electric Devices, Inc. 1888
Magnatrol Valve Corp. 1874
Magnetic Research Corp. 1823
Mallory & Co., Inc., P. R. 1748
Manning, Maxwell & Moore, Inc. 1807
Marconi Instruments 1835
Marsh Instrument Co. 1877
Marshalltown Mfg. Co. 1820
Measurements Corporation 1848
Mid-Century Instrumatic Corp. 1796
Midwestern Instruments ..... Inside Front Cover
Milford Rivet & Machine Co. 1887

Minneapolis-Honeywell Regulator Co., Industrial Division 1704, 1727, 1728, 1729, 1730, 1752
Moeller Instrument Company 1732
Moog Valve Co., Inc. 1761
Moser Jewel Company 1873

Nash Engineering Company 1821
New Hampshire Ball Bearings, Inc. 1710
New Hermes Engraving Machine Corp. 1820
Niagara Blower Company 1824
North American Instruments, Inc. 1886

Offner Electronics Inc. 1716-1717
Ohmart Corp. 1838
Ohmite Manufacturing Company 1859

Palmer Thermometers, Inc. 1852
Panellit, Inc. 1754
Parker Appliance Company 1834
Perkin Engineering Corporation 1695
Petrometer Corporation 1870
Philadelphia Thermometer Co. 1870
Post Machinery Co. 1883
Pritchard & Co. of California, J. F. 1812, 1813
Production Instrument Co. 1814
Progressive Service Co. 1872
Propulsion Development Laboratories 1866
Pyrometer Instrument Co. 1842

Radiation Inc. 1731
Radio Frequency Laboratories, Inc. 1880
Republic Manufacturing Co. 1872
Rex Rheostat Co. 1888
Robbins Aviation 1842
Rochester Manufacturing Co., Inc. 1816
Rubicon Company 1738

Sanborn Company 1833
Schaevitz Engineering 1737
Scherr Co., Inc., Geo. 1872
Sensitive Research Instrument Corporation 1696
Shallcross Manufacturing Company 1703
Shore Instrument & Mfg. Co., Inc. 1880
Siemens New York Inc. 1825
Smith Company, S. Morgan 1836
Sorensen & Company, Inc. 1713
Special Machines Company 1888
Stackpole Carbon Co. 1851
Standard Electric Time Company 1718-1719
Statham Laboratories 1817
Stromberg-Carlson 1863
Superior Electric Company 1749
Swartwout Company 1867

Technical Charts Incorporated 1841
Technique Associates, Inc. 1870
Tensitron, Inc. 1888

Uehling Instrument Co. 1884
Ultradyne Engineering Labs., Inc. 1888
Unertl Optical Co., John 1886

Vapor Recovery Systems Company 1840
Vector Electronic Company 1850
Veeder-Root Incorporated 1762

Wallace & Tiernan Incorporated 1799
Weckesser Co. 1884
Weksler Thermometer Corporation 1853
Welch Scientific Company, W. M. 1811
West Instrument Corporation 1829
Weston Electrical Instrument Corporation 1746
Wheelco Instruments Div., Barber-Colman Company 1879
Wilmad Glass Company, Inc. 1871
Winzeler Manufacturing & Tool Co. 1871

Zeiss, Inc., Carl 1886

NEW LITERATURE

Potentiometers. New 6-page folder presents maker's "Dipot" multiturn potentiometer which subdivides voltages obtained from matched resistors with a vernier potentiometer.—Servonics, Inc., 834 N. Henry St., Alexandria, Va.

Circle **538** on inquiry card.

TRANSISTORS, TUBES

Silicon Rectifiers. New 4-page Bulletins (DL-S-617, 618 and 615) present maker's grown junction silicon rectifiers types 1N543, 1N543A, 1N544 and 1N544A and full wave silicon rectifier type TI/680 designed for stable operation at high ambient temperatures.—Texas Instruments Inc., 6000 Lemmon Ave., Dallas 9, Texas.

Circle **539** on inquiry card.

Transistor. New 4-page Bulletin 2N175 describes and illustrates maker's junction transistor, germanium p-n-p alloy type for audio-frequency amplifier service.—Semiconductor Div., Radio Corp. of America, Harrison, N. J.

Circle **540** on inquiry card.

Rectifiers and Tubes. New 2-page Selection Chart ETD-1322 lists essential characteristics of 75 of maker's power rectifiers and control tubes.—General Electric, Schenectady 5, N. Y.

Circle **541** on inquiry card.

MATERIALS

Ductile Bismuth Wire. New 28-page Bulletin, second edition, presents description, properties and applications of maker's ductile bismuth wire with unique resistance-magnetic characteristic (Hall and Gauss effect).—Fitzpatrick Electric Supply Co., 444 Irwin St., Muskegon, Michigan.

Circle **542** on inquiry card.

Sealing Compound. New 20-page and 3-page technical reports present applications and properties of maker's "Loctite" liquid seal which hardens automatically in joints between close fitting metal parts to form a strong heat-and oil-resistant plastic seal.—American Sealants Co., Trinity College, P.O. Box 260, Hartford 6, Conn.

Circle **543** on inquiry card.

Berryllium Copper. New 4-page Technical Data Sheet 300 presents maker's beryllium copper strip giving applications, specifications and description of alloy.—Industrial Div., American Silver Co., Inc., 3607 Prince St., Flushing 54, N. Y.

Circle **544** on inquiry card.

Powder Coating. New 2-page folder describes maker's fluidized powder coating process, plastic welding kit and polythylene spray unit for laboratory and industrial use.—American Agile Corp., P.O. Box 168, Bedford, Ohio.

Circle **545** on inquiry card.

Vulcanized Fiber and Laminated Plastics. New 4-page bulletin describes the physical properties and use benefits of the maker's vulcanized fibre and laminated plastic.—National Vulcanized Fibre Co., Wilmington 99, Dela.

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1	26	51	76	101	126	151	176
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3	28	53	78	103	128	153	
4	29	54	79	104	129	154	
5	30	55	80	105	130	155	
6	31	56	81	106	131	156	
7	32	57	82	107	132	157	
8	33	58	83	108	133	158	
9	34	59	84	109	134	159	
10	35	60	85	110	135	160	
11	36	61	86	111	136	161	
12	37	62	87	112	137	162	
13	38	63	88	113	138	163	
14	39	64	89	114	139	164	
15	40	65	90	115	140	165	
16	41	66	91	116	141	166	
17	42	67	92	117	142	167	
18	43	68	93	118	143	168	
19	44	69	94	119	144	169	
20	45	70	95	120	145	170	
21	46	71	96	121	146	171	
22	47	72	97	122	147	172	
23	48	73	98	123	148	173	
24	49	74	99	124	149	174	
25	50	75	100	125	150	175	

New Instruments

201	226	251	276	301	326
202	227	252	277	302	327
203	228	253	278	303	328
204	229	254	279	304	329
205	230	255	280	305	330
206	231	256	281	306	331
207	232	257	282	307	332
208	233	258	283	308	333
209	234	259	284	309	334
210	235	260	285	310	335
211	236	261	286	311	336
212	237	262	287	312	337
213	238	263	288	313	338
214	239	264	289	314	339
215	240	265	290	315	340
216	241	266	291	316	341
217	242	267	292	317	342
218	243	268	293	318	343
219	244	269	294	319	344
220	245	270	295	320	345
221	246	271	296	321	346
222	247	272	297	322	347
223	248	273	298	323	
224	249	274	299	324	
225	250	275	300	325	

New Literature

401	426	451	476	501	526	551
402	427	452	477	502	527	552
403	428	453	478	503	528	553
404	429	454	479	504	529	554
405	430	455	480	505	530	555
406	431	456	481	506	531	556
407	432	457	482	507	532	557
408	433	458	483	508	533	558
409	434	459	484	509	534	559
410	435	460	485	510	535	560
411	436	461	486	511	536	561
412	437	462	487	512	537	562
413	438	463	488	513	538	563
414	439	464	489	514	539	
415	440	465	490	515	540	
416	441	466	491	516	541	
417	442	467	492	517	542	
418	443	468	493	518	543	
419	444	469	494	519	544	
420	445	470	495	520	545	
421	446	471	496	521	546	
422	447	472	497	522	547	
423	448	473	498	523	548	
424	449	474	499	524	549	
425	450	475	500	525	550	

NEW LITERATURE

MISCELLANEOUS

American Standards. New 20-page booklet describes ways standards become nationally-accepted and approved as American standards and tells who makes these standards, why, and who uses them.—Dept. PR., American Standards Association, 70 E. 45 St., New York 17, N. Y.
Circle **547** on inquiry card.

Storage Cabinets. New 16-page bulletin describes maker's line of storage cabinets featuring the "Haz-Bin" cabinets with plastic drawers.—General Industrial Co., 5736B Elston Ave., Chicago 30, Ill.
Circle **548** on inquiry card.

Design Service. New 6-page folder describes maker's design service for special machinery, material handling, tooling, plant layout and automation. —Parmco Engineering Co., 8129 E. Nine Mile Rd., Van Dyke, Mich.
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Lettering Aid. New 2-page leaflet presents maker's lettering aid guide for free-hand lettering.—Rapi Design, Inc., Box 592, Glendale, Calif.
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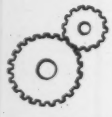

MECHANICAL COMPONENTS

Electrical, Mechanical Components. New 16-page catalog "This Month," Summer issue, presents line of timers, motors, condensers, blowers, relays, counters, valves, lab ovens, etc., available from distributor.—Herbach & Rademan Inc., 1204 Arch St., Phila. 7, Pa.
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Automatic Lubrication. New 2-page Instruction Sheet gives service instructions for maker's Type M automatic lubricators.—"Service," Bijur Lubricating Corp., 151 W. Passaic St., Rochelle Park, N. J.
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Miniature Couplings. New 4-page Bulletin MC-100 presents maker's line of miniature flexible couplings for power transmission.—Thomas Flexible Coupling Co., Warren, Pa.
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Fasteners. The 12-page Catalog 11B presents maker's line of self-locking screws, bolts, nuts and special fasteners with specifications.—Nylok Corp. Elmira Heights, N. Y.
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FABRICATION, TOOLS

Coil Winder. New 2-page leafle presents maker's "Midget" toroid co winder that winds off the inside o shuttle.—Electro Devices Company Inc., 580 Main Street, Wilmington Mass.
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Wire Cutter and Stripper. New 4 page Bulletin 4554 presents maker' "Mark II" wire cutter and stripper.— Technical Devices Co., 2340 Centinel Ave., Los Angeles 64, Calif.
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Splicing Tools. New 12-page booklet presents instructions and application information for maker's "Scotchcast" splicing kits.—Minnesota Mining and Manufacturing Co., Dept. D6-196, St. Paul, Minn.
Circle **557** on inquiry card.

Flux. New 4-page Catalog 56C presents information on selection of corrosive and non-corrosive fluxes for metal joining from Alnico to zinc.— Anchor Metal Company Inc., 244 Boerum St., Brooklyn 6, N. Y.
Circle **558** on inquiry card.

Tools. New 2-page bulletin describes maker's beryllium copper marine safety tools.—Beryllium Corp., Reading, Pa.
Circle **559** on inquiry card.

Injection Molding Machine. New 8 page Bulletin 565 describes maker' "Model 701" 2-ounce automatic injection molding machine and gives complete specifications.— F. J. Stokes rp., 5500 Tabor Rd., Phila. 20, Pa.
Circle **560** on inquiry card.

Hydro-Pneumatic Accumulators. w 8-page Bulletin 900, Pension A, sents maker's hydro-pneumatic ac mulators for hydraulic molding ipment.—Greer Hydraulics, Inc., w York International Airport, Jaica 30, N. Y.
Circle **561** on inquiry card.

Load Cycle Counters. New 4-page letin presents maker's load cycle nters with telemetering feature.— m Meter, Inc., 1100 Hilton Rd., ndale, Detroit 20, Mich.
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Machinery Mounts. New 4-page der describes maker's "Unisorb" chinery mounts for vibration con l.—Felters Co., 232 South St., Bos 11, Mass.
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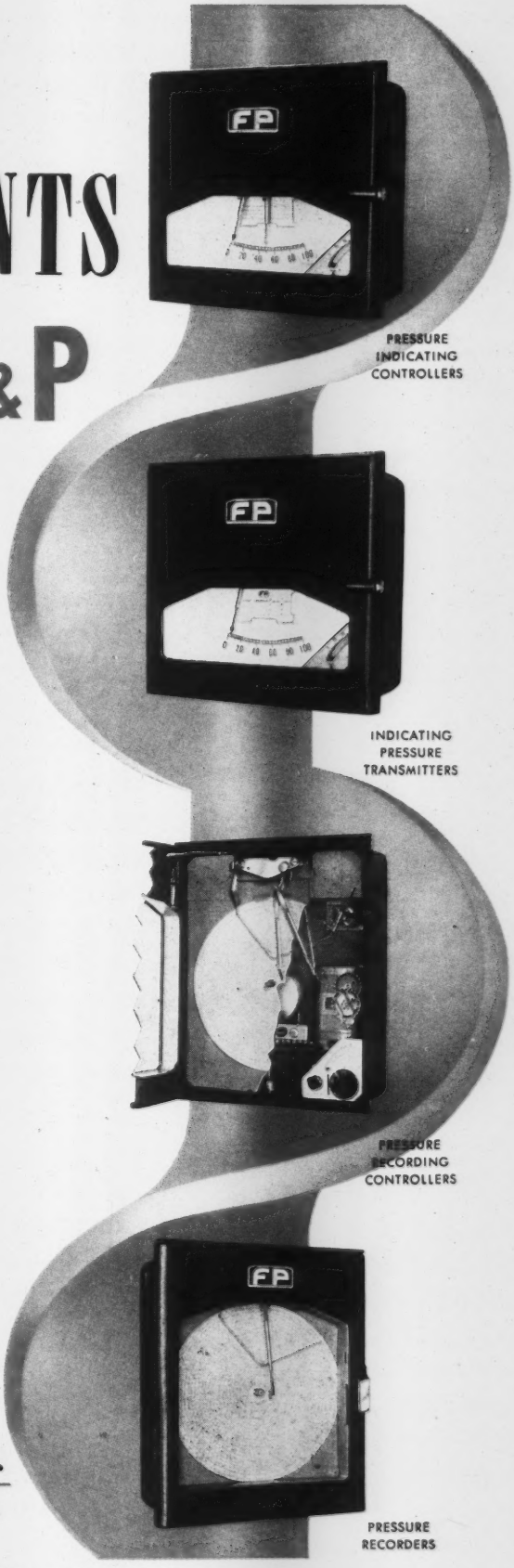

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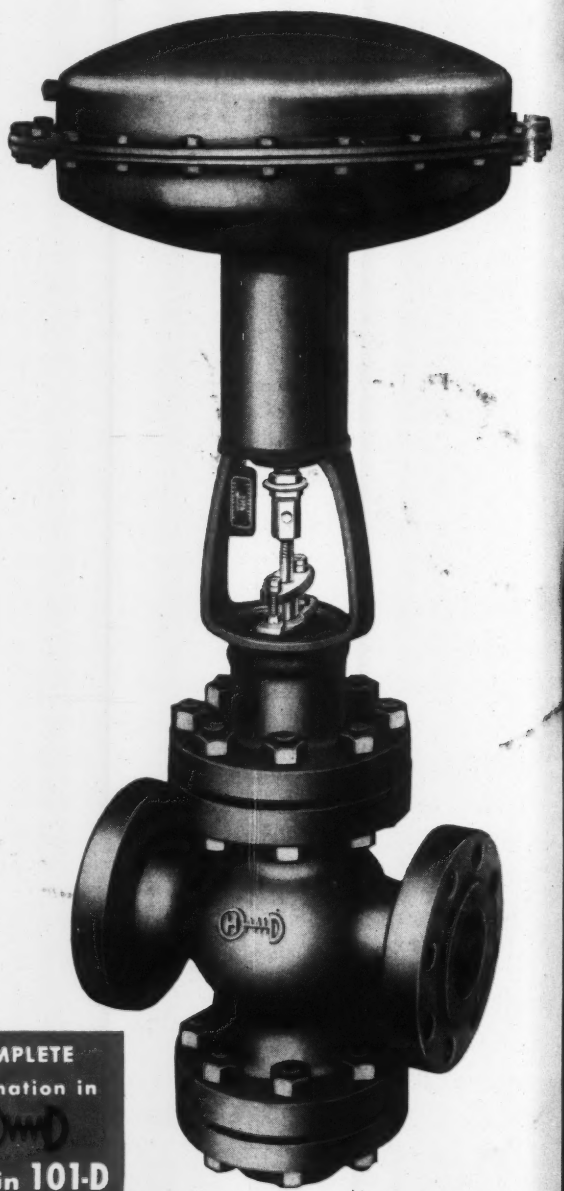

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